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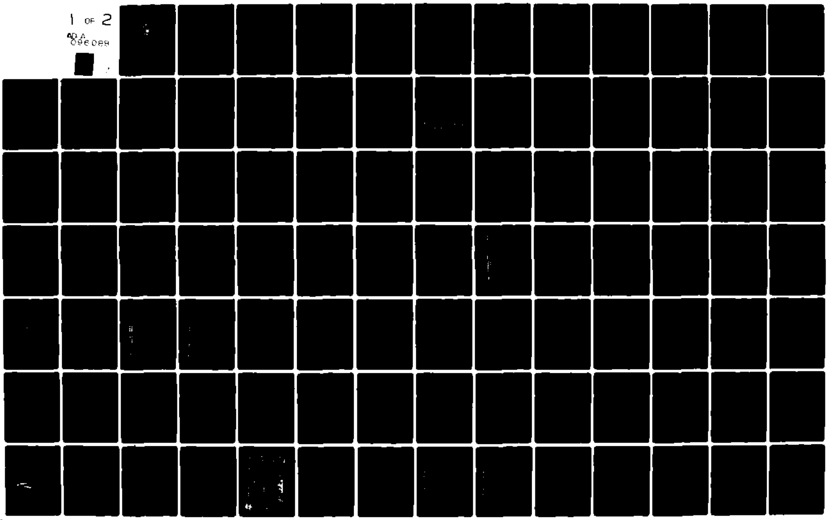

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NAVAL POSTGRADUATE SCHOOL

Monterey, California

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THESIS

CHALLENGE FOR OPERATIONAL EXPERIENCE
FEEDBACK IN AIRCRAFT DESIGN:
AN AIRCRAFT DESIGN EXAMPLE.

by

Stanley John Sweikar, Jr.

September 1979

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Prepared for:

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Since the early 1960s, the Department of Defense and the air transport industry have seen a downward trend in the number of new aircraft production starts. One of the effects of fewer new development programs has been a declining level of practical design experience acquired by individual engineers in aerospace design organizations. When compared to the growing need for design experience build-up, a result of expanding technology

(20. ABSTRACT Continued)

the situation becomes worse. To acquire needed levels of practical design experience, feedback and utilization of operational experience is becoming increasingly important. Responsive feedback systems are used by the commercial air transport industry for providing operational experience applicable to product improvement and new development programs. Feedback systems in Naval aviation provide data and information for application primarily in areas of manpower and material management. This thesis analyzes and discusses the present situation and basic needs for operational experience feedback in aircraft design.

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CHALLENGE FOR OPERATIONAL EXPERIENCE FEEDBACK IN AIRCRAFT DESIGN

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Submitted in partial fulfillment of the
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ABSTRACT

Since the early 1960s, the Department of Defense and the air transport industry have seen a downward trend in the number of new aircraft production starts. One of the effects of fewer new development programs has been a declining level of practical design experience acquired by individual engineers in aerospace design organizations. When compared to the growing need for design experience build-up, a result of expanding technology, the situation becomes worse. To acquire needed levels of practical design experience, feedback and utilization of operational experience is becoming increasingly important. Responsive feedback systems are used by the commercial air transport industry for providing operational experience applicable to product improvement and new development programs. Feedback systems in Naval aviation provide data and information for application primarily in areas of manpower and material management. This thesis analyzes and discusses the present situation and basic needs for operational experience feedback in aircraft design.

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GLOSSARY OF ACRONYMS

ADP	Automated Data Processing
AFPRO	Air Force Plant Representatives Office
ATA	Air Transport Association of America
BIS	Board of Inspection and Survey
CAD	Computer-Aided Design
CETS	Contractor Engineering Technical Services
CFA	Cognizant Field Activity
CNO	Chief of Naval Operations
CRT	Cathode Ray Tube
DCAS	Defense Contractor Administrative Services
DDC	Defense Documentation Center
DoD	Department of Defense
DR	Deficiency Report
ECP	Engineering Change Proposal
FAA	Federal Aviation Administration
FLAG	Feedback Loop Action Generation
FMSO	Fleet Material Support Office
GIDEP	Government-Industry Data Exchange Program
LCC	Lockheed-California Corporation
MDCS	Maintenance Data Collection Subsystem
MIS	Management Information System
NAESU	Naval Aviation Engineering Services Unit
NAMSO	Navy Maintenance Support Office

NAVAIRSYSCOMHQ	Naval Air Systems Command Headquarters
NAVAIRTESTCEN	Naval Air Test Center
NAVPRO	Navy Plant Representative Office
NAVSAFCEN	Naval Safety Center
NETS	Navy Engineering Technical Services
NPE	Navy Preliminary Evaluation
NWESA	Naval Weapons Engineering Support Activity
OMB	Office of Management and Budget
OSDS	Operational Support Data System
PM	Program Manager
PMA	Program Manager Acquisition
RDT&E	Research, Development, Test and Evaluation
R&M	Reliability and Maintainability
RTR	Report of Test Results
SLEP	Service Life Extension Programs
T&E	Test and Evaluation
TMIS	Technical Management Information System
TR	Technical Report
Y/S	Yellow Sheet

ACKNOWLEDGEMENT

The assistance provided by the many individuals contacted during the course of this thesis was invaluable. Their candor and willingness to contributed to what upper-management may consider a non-glamour issue not only made study of operational experience feedback and its application to the design process possible, but also potentially useful.

All contributions are appreciated and are hereby gratefully acknowledged.

I. INTRODUCTION

Why is it that the Department of the Navy frequently experiences similar or repetitive undesirable design characteristics from one aeronautical weapon system development program to the next? Why is it that the many enhancing design characteristics seen on currently deployed and many retired aircraft are not exploited during new development programs? Questions of this type, asked by fleet operating units and test and evaluation activities, have surfaced as a result of the rapidly increasing number of engineering change proposals, escalating life cycle costs, under-achieved mission readiness rates, and in many cases, incompatibilities with military operating environments.

Although the above questions reflect a viable problem, they are not intended to imply that the Navy is unconcerned about operational experience applicable to design of aircraft weapon systems. On the contrary, ambitious programs were undertaken by the Naval Air Systems Command during the 1970s on grappling the many problems associated with systems effectiveness parameters applicable to major system acquisition. The programs emphasized utilizing available operational experience for developing specific and more meaningful specification requirements.

While considerable effort has been expended on developing specification requirements, little effort has been allocated

to improving operational experience feedback from fleet operators to industry designers. Inadequacies in current feedback systems inhibit effective utilization of operational experience in the front end of new design. Hence, it is this notion that was pursued by this study.

A. PURPOSE OF THESIS

The purpose of this thesis is twofold. First, to investigate, analyze, and describe the present situation and basic trends regarding feedback of operational experience from user to manufacturer of commercial and military aircraft; and second, to summarize and discuss the findings.

B. SCOPE OF STUDY

Constraints of time and resources limited this investigation to the Department of the Navy for military aircraft and to the Lockheed-California Company for commercial transport aircraft.

The scope of this study is confined to:

1. Investigating the validity and need for feedback of operational experience;
2. Studying feedback sources on the commercial side of the aerospace industry;
3. Studying current Naval Aviation feedback sources; and
4. Determining current situation for feedback of operational experience to designers.

To avoid later confusion, it is imperative that the reader understands that this thesis addresses experience feedback only. The equally important topic of experience transfer is not within the scope of study. Sub-section E of the Introduction and Figure 1 briefly differentiate the two. While feedback is basic to operational experience build-up within a given design engineering organization, transfer provides for sharing feedback experience with other organizations as well as distributing it to those individuals who have a "need to know" inside an organization.

C. METHODOLOGY EMPLOYED

One of the difficulties encountered in the study was finding reference sources, government or industry, that addressed the subject directly. Extensive reasearch revealed little work has been published in this topic area.

The major source of information used as the primary basis for study was obtained through extensive personal interviews conducted by the author. All interviews were begun with a complete explanation of the nature of the research. The interviews were not formalized but were tailored to the interviewee and were intended to provide the author with an insight into the atmosphere, attitude and functions of the organization being interviewed. The goal was to establish a rapport with the interviewee and then find out his candid opinions on the various aspects of operational experience

compilation, feedback and utilization. Organizations contacted and interviewed during the course of the study are listed in Appendix A.

D. GLOSSARY OF TERMS

The following brief descriptions are provided to clarify some basic terms as treated by this study.

1. Design has been defined in many ways. For the present purposes, among the many aspects of design, an emphasis on learning from past experience is of special importance.
2. Aircraft Design offers an outstanding example for the complex demands and responsibilities in the field of design. Performance, safety, cost, weight, reliability and maintainability are some of the contradictory demands which have to be met and reconciled. The responsibilities of the designer extend over the whole service life of the aircraft, with innumerable combinations of environmental and operational conditions.
3. Data are the original and detailed representations of events in the physical world. Data are the raw material from which information is manufactured by operations known collectively as data processing.
4. Information can be thought of as processed data or data given context. Information is that knowledge that can be applied in current operations.

5. Experience is a special type of information. The word experience has its origin in the Latin "from having gone through" -- in contrast to the word theory, which is derived from the Greek "to look at." Experience refers to having gone through a real-life process. A very large number of parameters may be involved and it is of paramount importance to separate essential from non-essential parameters.

6. Operational has to do with the operation or use of a system, sub-system, component in the environment and for the purpose which it was intended.

7. Feedback, in the present context, pertains to the flow of operational data, information, and/or experience from the user back to the contractor.

8. Transfer pertains to the dissemination or exchange of operational data, information, and/or experience among contractors, as shown in Figure 1, or among individuals within an organization.

9. Experience Feedback in Aircraft Design is concerned with transmitting "lessons learned" in operational experience to the organization responsible for the product.

10. Experience Transfer in Aircraft Design is concerned with transmitting "lessons learned" in operational experience to designers throughout the industry who have a "need to know."

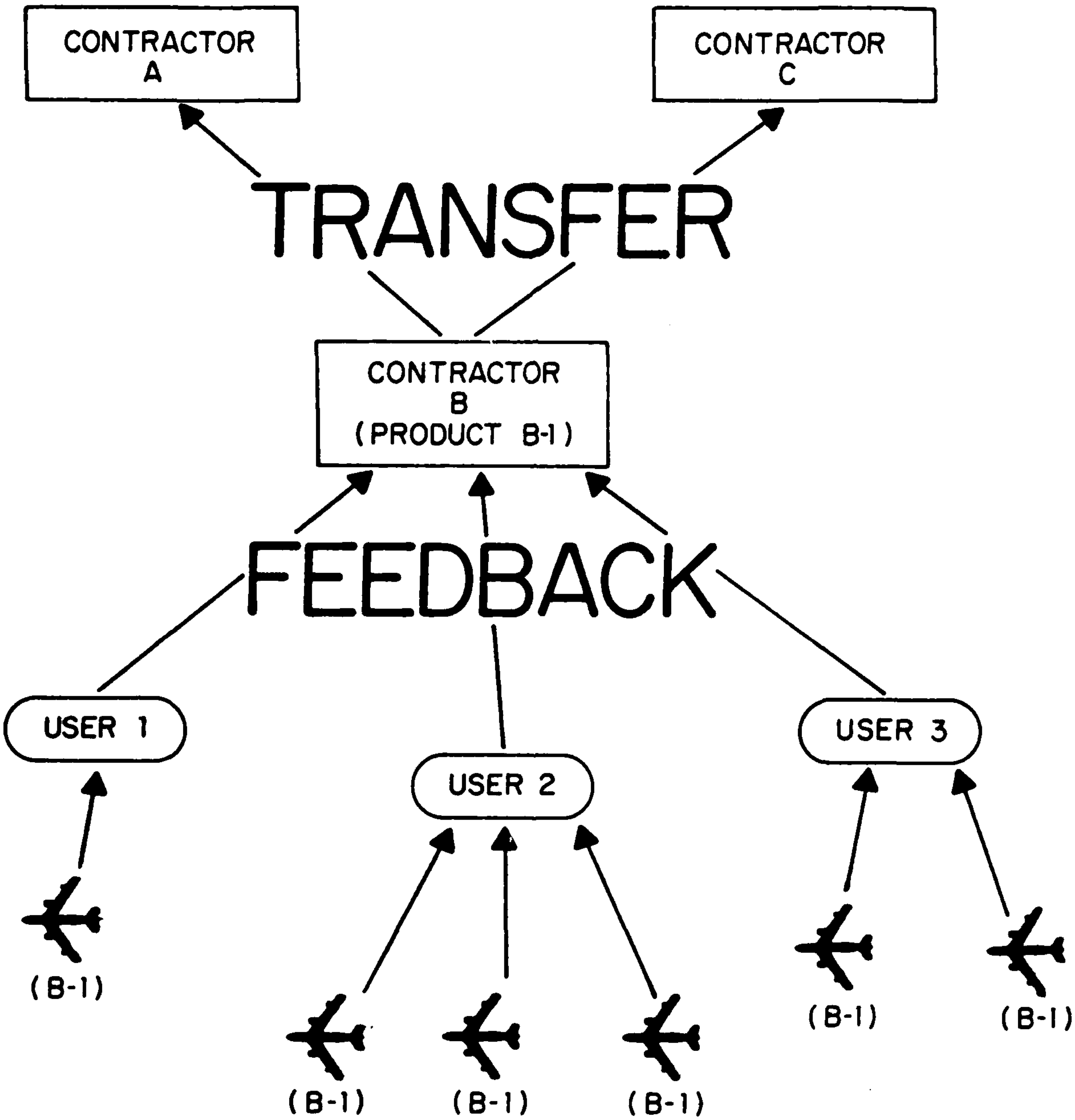

Figure 1: FEEDBACK FLOW AND TRANSFER SIMPLIFIED.

II. BASIC TRENDS IN AIRCRAFT DESIGN

A. BACKGROUND

Without doubt, the best and most effective implementation of operational experience occurred during the pioneering years of powered flight. As both designer and user, the early pioneers, such as the Wright Brothers and Glenn Curtiss, were able to readily learn from their previous designs and immediately apply the experiences to their next design decision. During the infant years of aviation, design groups remained small. However, as aviation grew into an industry, and the technology associated with flight became more involved, the likelihood of the designer also being the ultimate user became rare. Nonetheless, the customer or ultimate user of these early aircraft, more often than not, worked hand-in-hand with the designer in an effort to gain the best possible design consistent with technology and operational experience of that time.

By the early 1930s, designers knew that the successful aircraft of the next generation would be more complex with retractable landing gear and all the other emerging refinements of variable-pitch propellers, wing flaps, control surface trim tabs, autopilot, de-icing equipment and radio navigation capabilities. The talent required to successfully design and build an aircraft of this complexity was beyond the ability of the "jack-of-all-trades" designer of

the time. Required were the coordinated inputs from a number of growing aeronautical specialists in such disciplines as aerodynamics, structures, propulsion, hydraulics, and avionics. Hence, the design organization was born.

During the 1960s, the aircraft industry sought to improve the rapport between designer and user by introducing formal feedback systems by which operational experience from past aircraft development programs could be compiled, transferred, and utilized on derivative or next generation development programs. This interest largely resulted from rapidly escalating program development costs and the "hard-nosed" position taken first by the air transport industry and later by the Department of Defense (DoD) to improve life-cycle costs through improved reliability and maintainability.

B. FEWER NEW DEVELOPMENT STARTS

A long-term reduction in the number of new development starts for DoD began in the second half of the 1950s. Trend data indicates a steady declining number of new aircraft production starts. The trend as shown in Figure 2 appears to be approaching an asymptote of just under one when taking a seven year moving average. This equates to a projected 1.5 new starts between 1985-1995. [18:37][1]

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[1]This notation is used throughout the report for sources of major reference. The first number is the source listed in the List of References. The second number is the page in the source.

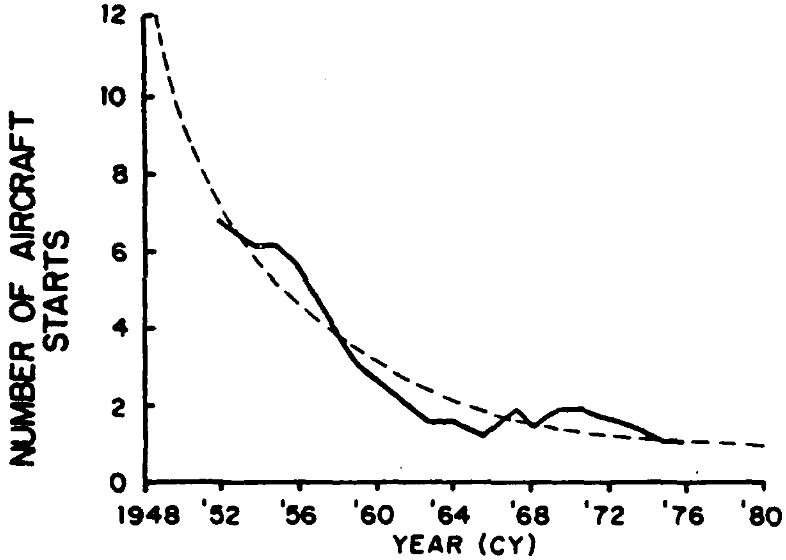


Figure 2: DOWNWARD TREND IN NEW MILITARY AIRCRAFT PRODUCTION STARTS (SEVEN-YEAR MOVING AVERAGE) [18:38]

This downward trend has had an impact on all military aircraft programs including fighter, attack, special mission, transport, utility and helicopter types. Illustrative of the trend is Figure 3, which depicts specific new development program starts for tactical (fighter and attack) aircraft. Of particular note is the slowdown in prototype development for the decade between 1959 and 1969. Only two new starts occurred during the period, largely a result of McNamara's "paper competition" policies that disallowed prototype development. The spurt of new programs begun during the early 1970s was most likely a "catch-up" of programs postponed or suppressed during the 1960s.

The commercial air transport industry experienced a similar downturn in new aircraft developments. Current inventory airline flight equipment, including Boeing B707/B727/B737/B747, McDonnell Douglas DC-8/DC-9/DC-10, and Lockheed L-1011 aircraft, are a product of the 1950s and 1960s. Until Boeing's early 1979 announcement to launch development of their next generation B757 and B767 aircraft, the industry had not seen a new development start for a decade.

Greater periods of lapsed time between military and commercial aircraft development programs, a result of fewer new starts, has had an adverse effect on retained employment of experienced designers in the industry, commercial and military alike.

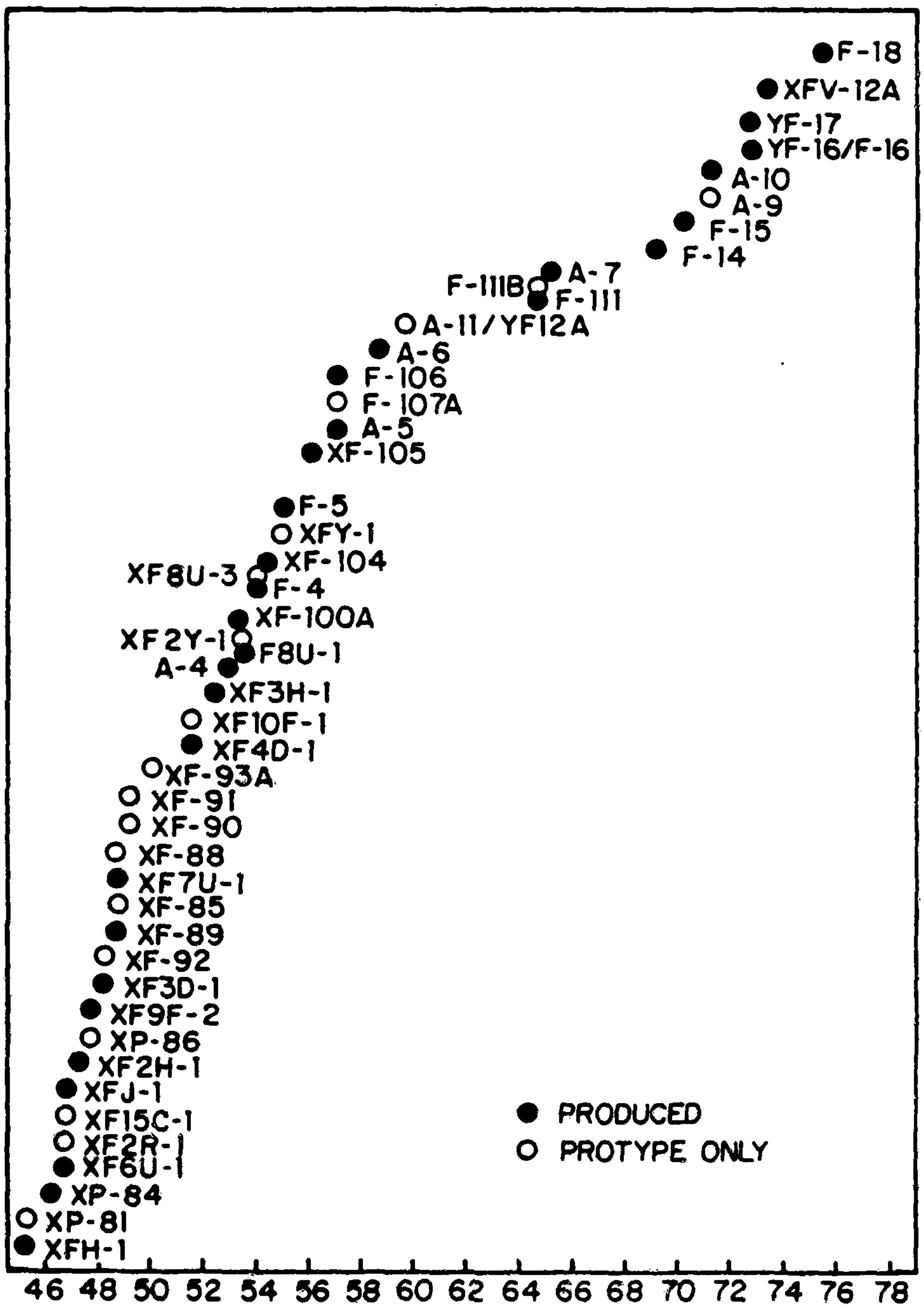


Figure 3: TACTICAL AIRCRAFT DEVELOPMENT PROGRAMS [2:24]

C. DETERIORATING DESIGN TEAM CONTINUITY

Maintaining design team continuity is another of the growing concerns to the aerospace industry. The era of fewer new starts and resultant excess engineering capacity has ushered in disenchantment among aircraft designers and engineering professionals for long-term career opportunities in the industry. Many of these experienced professionals have pursued more promising career opportunities in another industry. Others are "job-hopping" to companies that have been successful in landing contracts for new development starts.

Continuity within engineering design teams is obviously important and was recognized as such by industry veteran Mr. Edward H. Heinemann in a presentation on "New Airplane Development." Heinemann stated:

> Successful manufacturers the world over have found continuity of design and manufacture a necessity. Furthermore, three to five projects in various stages of development are necessary at all times to remain competitive and retain healthy design organizations. Continuity is one of the most important key words in this business. [10:1327]

Similar concern over continuity is shared by the Naval Air Systems Command (NAVAIRSYSCOM). In a presentation on "NAVAIR Program Analysis and Evaluation (Past Experience)" to the Naval Aviation Executive Institute, Mr. George A. Spangenburg expressed his concern for the loss of technical continuity within the Systems and Engineering Group (NAVAIR-05) of the NAVAIRSYSCOM. [25] Spangenburg, who retired

from NAVAIR-05 as a technical director in the mid-1970s, indicated the key factors resulting in continuing loss of NAVAIR technical continuity include fewer new starts, long-term reduction in NAVAIR manning levels for engineering/technical specialists, and changing aircraft weapon system procurement policies.

D. SCARCITY OF EXPERIENCED AEROSPACE ENGINEERS

Aerospace designers are becoming an "endangered species" in the nation's aerospace industry. The reduction in the supply of experienced designers has been largely a result of fewer needs by industry and better career opportunities in analytical specialization.

Also contributing to the scarcity of engineering personnel was the severe economic recession experienced by the industry during the early 1970s, and the anti-technology movement among American youth inspired by the Vietnam war, both of which were responsible for directing many college students away from aerospace.

Termination of the supersonic transport development program in conjunction with waning design engineering requirements for the B747, DC-10 and L-1011 wide-body programs produced large scale lay-offs among engineers. The first to receive employment termination notices were those personnel with least seniority and experience; thus, most of the reduction in engineering manpower took place among young engineers. Fewer young engineers are now

interested in entering this industry typified by dramatic economic ups and downs. Consequences of this situation will be seen in the 1980s when comparatively few experienced engineers will be available to fill the void created by attrition of the senior engineering force. [17:37]

The Boeing Company is already feeling the "sting" in the shortage of aerospace engineers required for development of its new B757 and B767 jet airliners. To overcome this shortage, Boeing has undertaken a unique method to build up its engineering staff. It is borrowing engineers from other aerospace contractors attempting to win lucrative subcontracts in the B757 and B767 programs. "We simply told them that without the engineers there would be no subcontract awards," says Boeing's Director of Personnel, Frank Gregory. "The engineer shortage is so severe that it was a do-or-die situation." [20:49]

While Boeing's great "engineer grab" may provide the numbers of engineers required for the B757 and B767 projects, it must be recognized that many will lack the "home-grown" experience and expertise unique to the design of jet airliners upon which Boeing has built a world-wide reputation.

E. LOWER LEVELS OF EXPERIENCE BUILD-UP

Lower comparable levels of experience build-up per unit of time in hardware design by junior design engineers, also a result of fewer new starts, is yet another concern. Attainment of the many practical considerations and skills

for application in the hardware design phase of the design process comes primarily from experience. Dr. Rene H. Miller, MIT's Aeronautics and Astronautics Department head, is of the opinion that the engineering involved in detailed hardware design requires less of what is taught in the universities than of what is taught by experience [12:29]. Without repetitive on-the-job design assignments an appreciation of past design experience and its influence on future design efforts is most difficult to achieve.

F. GREATER FINANCIAL RISK

Historically, aeronautical weapon systems have become increasingly more complex with each passing generation of aircraft. For the most part, this complexity is a direct result of incorporating high technology and more demanding systems performance requirements.

Directly proportional and related to the trend of increasing complexity is the trend of increasing aircraft cost. It can be shown that the unit cost of military aircraft is increasing at an exponential rate. The historical trend of escalating unit cost for tactical aircraft is shown in Figure 4. From the Wright Brothers to today's high technology, high performance F-18, the cost of an individual military aircraft has invariable grown by a factor of four every 10 years. [1:63]

The financial risk associated with military aircraft development programs lies more with DoD than with the major

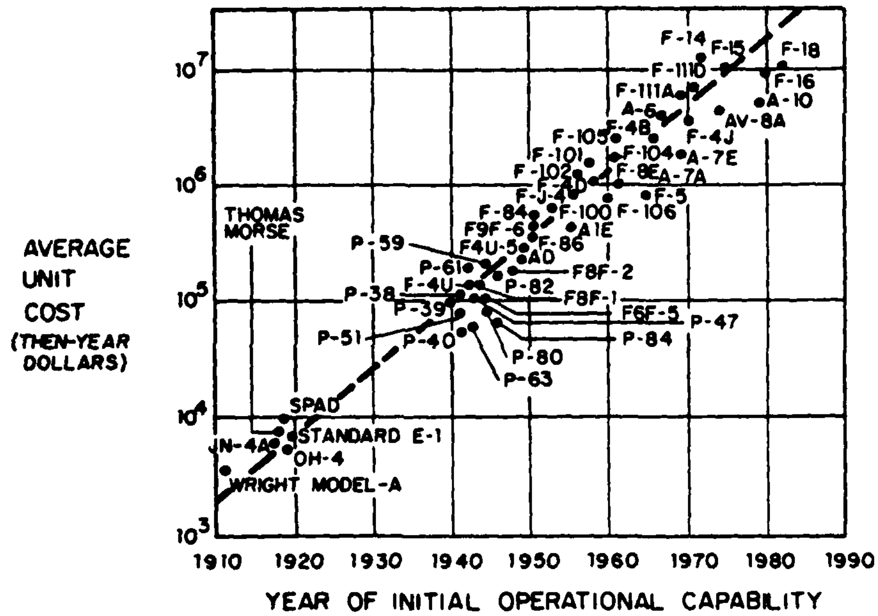


Figure 4: TREND OF ESCALATING COST OF TACTICAL AIRCRAFT [1:62]

manufacturers. Survival of a development program is predicated all too often on the outcome of the many encounters with the various steps in the budget cycle.

The commercial air transport industry has seen similar, if not greater cost escalations in its flight equipment. Despite lesser levels of technology required of transport aircraft, due to the absence of advanced state-of-the-art weapons fire-control and delivery systems required on military aircraft, unit cost for today's typical wide-body is in excess of 35 million dollars as compared to unit cost of several hundred thousand dollars for the typical transport of the 1930s. Development costs for the current generation of American-built wide-body transports has been a staggering $1.0 to $1.5 billion for each design produced (B747, DC-10, L-1011). Such figures and the cash-flow typical of commercial development programs as shown in Figure 5, clearly portrays the nature of financial risk undertaken by the prime contractors, subcontractors, suppliers and the supporting banking community.

The risk for the major manufacturers is centered on the probability of recovering massive nonrecurring costs for airframe and propulsion system design, development, and Federal Aviation Administration (FAA) certification. Longer production runs (larger sales volume) are now required to recover costs and make a profit.

F-1 TYPICAL COMMERCIAL PROGRAM CASH-FLOW

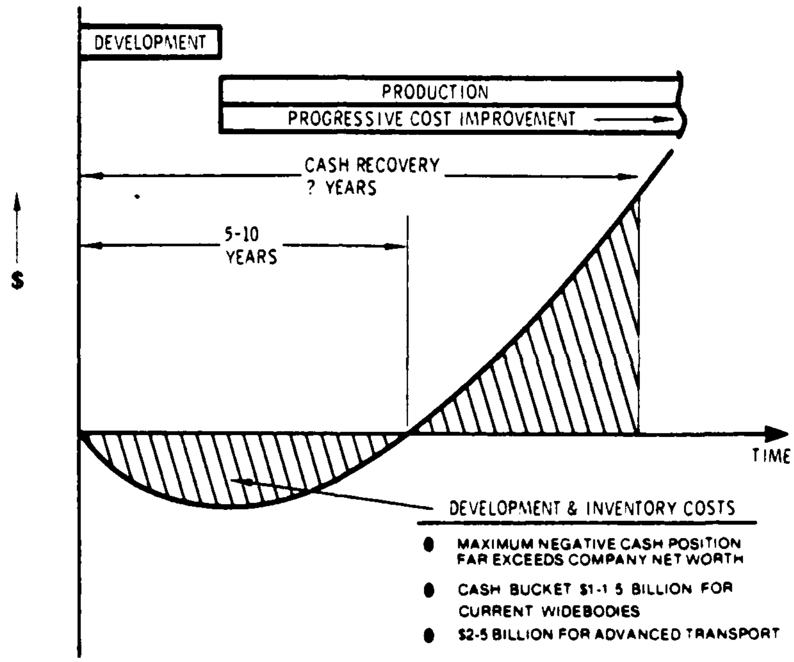


Figure 5: TYPICAL COMMERCIAL AIRCRAFT PROGRAM CASH FLOW [24:26].

G. INCREASING ENGINEERING CHANGE PROPOSALS EXPENDITURES

Increasing aircraft complexity has precipitated yet another trend, that of increasing expenditures for modifications to production military aircraft. These modifications are a direct result of Engineering Change Proposal (ECP) action by both the military user and the manufacturer. Lacking statistical information concerning the number of ECP actions, the Naval Weapons Engineering Support Activity (NWESA) directed study efforts at financial expenditures for modifications resulting from incorporating ECP in naval aircraft. If the deviant behavior associated with the Vietnam War is ignored, expenditures for ECP actions have increased steadily since 1963. Through linear extrapolation, NWESA projected ECP expenditure to $0.9 million and $1.4 million respectively per aircraft for 1985 and 1995 in 1977 dollars, an increase of 75% and 153% respectively over 1977 expenditures. [18:37]

H. ERA OF COMPUTER-AIDED DESIGN

Rapid advancements in computer technology of the 1970s has made possible rapid advancement of analytical and graphical tools for computer-aided design (CAD). Through interactive software packages, it is no longer necessary to build hardware prototypes to investigate performance, structures, reliability, maintainability and cost. The designer is now able to develop computer models of hardware solutions and obtain visual animated answers to design questions.

CAD has become an extremely complex process involving interrelationships among design phases, design applications and design functions. Just recently, interactive programs for applying operational experience have been made available to assist in the design function.

I. EMPHASIS ON SYSTEM OPTIMIZATION

History shows that systems performance has been the traditional driving force behind military aircraft development programs. This push for performance, almost to the exclusion of all other system characteristics, has resulted in tactical aircraft which have poor reliability and are difficult and costly to maintain. These two factors, more than any others, have resulted in unacceptable levels of operational readiness and aircraft availability in fleet operating units.

The air transport industry had long recognized the need for an optimal balance between aircraft performance, reliability, maintainability and life-cycle costs if they were to remain a viable industry. By the late 1960s, the military services, in view of rapidly growing operating and support costs coupled with poor operational readiness, began addressing design goals for systems optimization. Since the early 1970s, major design emphasis has gone into reliability and maintainability (R&M) for such optimization. R&M have been acknowledged as primary life cycle cost "drivers" which

directly affect the operation and support costs for aircraft, military and commercial, throughout their service lives.

J. CHANGING DoD SYSTEMS ACQUISITION POLICY

The military aerospace industry has been experiencing yet another change during the past several years. In April 1976, the Office of Management and Budget (OMB) issued new policies for the acquisition of major systems by all executive branch agencies. Essentially, the new policies, OMB Circular A-109, strive to assure effectiveness and efficiency in the process of acquiring major systems. [19:3-4] Policies thought to have significant DoD/Industry interface in acquisition of future aircraft weapon systems are those that direct the acquiring agency to:

1. Express needs and program objectives in mission terms rather than specific capabilities or equipment requirements to encourage innovation and competition in operating, exploring and developing alternative system design concepts;
2. Place emphasis on the initial activities of the system acquisition process to allow competitive exploration of alternative system design concepts in response to mission needs; and
3. Rely on private industry for its needs for products and services in accordance with the policy established by OMB circular A-76.

While A-109 may well improve the efficiencies associated with aircraft acquisition schedule and cost, the benefits to be derived by reducing the customer's and ultimate user's role in system and subsystem design may detract from operator service suitability. In the past, time-consuming reconciliation of opinions based on experience by operators, NAVAIRSYSCOM staffs, in-house Navy laboratories and industry had a positive effect in the design decision making process.

Under A-109, utilization of operational experience is questionable. The concept and approach to design will now be developed competitively, using relatively short-term contracts in response to solicitations which express end-objective functions a bidding contractor's system must perform. Contractors are forced by competition to follow disciplined processes to deliver and justify their best design proposals on a timely basis. [5:13]

III. ROLE OF OPERATIONAL EXPERIENCE

The basic trends encountered by aerospace design organizations during the 1970s have been discussed in the previous section of this study. Many of these trends are thought to have a negative or deteriorating effect on aerospace design capability. These trends, when coupled with a less than optimum flow of operational experience from the user or operator back to the front end of new hardware design, further detract from design capability.

This section first investigates practical know-how as the ingredient essential to good hardware design. It then relates the importance of experience feedback as a means to preserve aircraft design expertise in government and industry new development programs.

A. THE DESIGN PROCESS

The design process consists of a hierarchical sequence, beginning with ideas and concepts and ending with manufacturing instructions and, if necessary, government product certification. Within this sequence, hardware design correlates best with the practical aspects of operational experience and is the event that deserves most attention by this study. Haupt, in discussing design hierarchy, describes hardware design as follows: [17:8-9]

> Within the constraints imposed by the chosen configuration, it is concerned with the actual hardware of structures and systems. Alternative solutions and tradeoffs have to be considered just as in parametric studies -- but now the practical level of hardware replaces the abstract level of parameters. Each component part is analyzed from the separate viewpoints of function, strength, cost, reliability, producibility, maintainability, etc. Structural and functional tests may be required for verification. The emphasis is on engineering know-how.

Hardware design can also be thought of as a conversion process -- converting quantitative input requirements into qualitative design solution outputs. Application of practical know-how is the primary element in the conversion process. Illustrative of the hardware design event in the design process is the example shown in Figure 6. It portrays the typical process in gross terms as applied to landing gear design. The success or failure of hardware design in terms of systems performance and life cycle costs is keyed to designer know-how.

Know-how, ideally the blending of latest technology, existing engineering knowledge and operational experience, is what produces optimum hardware configuration. Of these three forms of engineering design know-how, operational experience can only be utilized through very close liaison between designer and user shown in Figure 7. This is perhaps the weakest link in the chain of design responsibility. Theory indicates that this link is essential for optimal hardware design. However, even where good liaison seems to exist between customer and manufacturer, it has been concluded

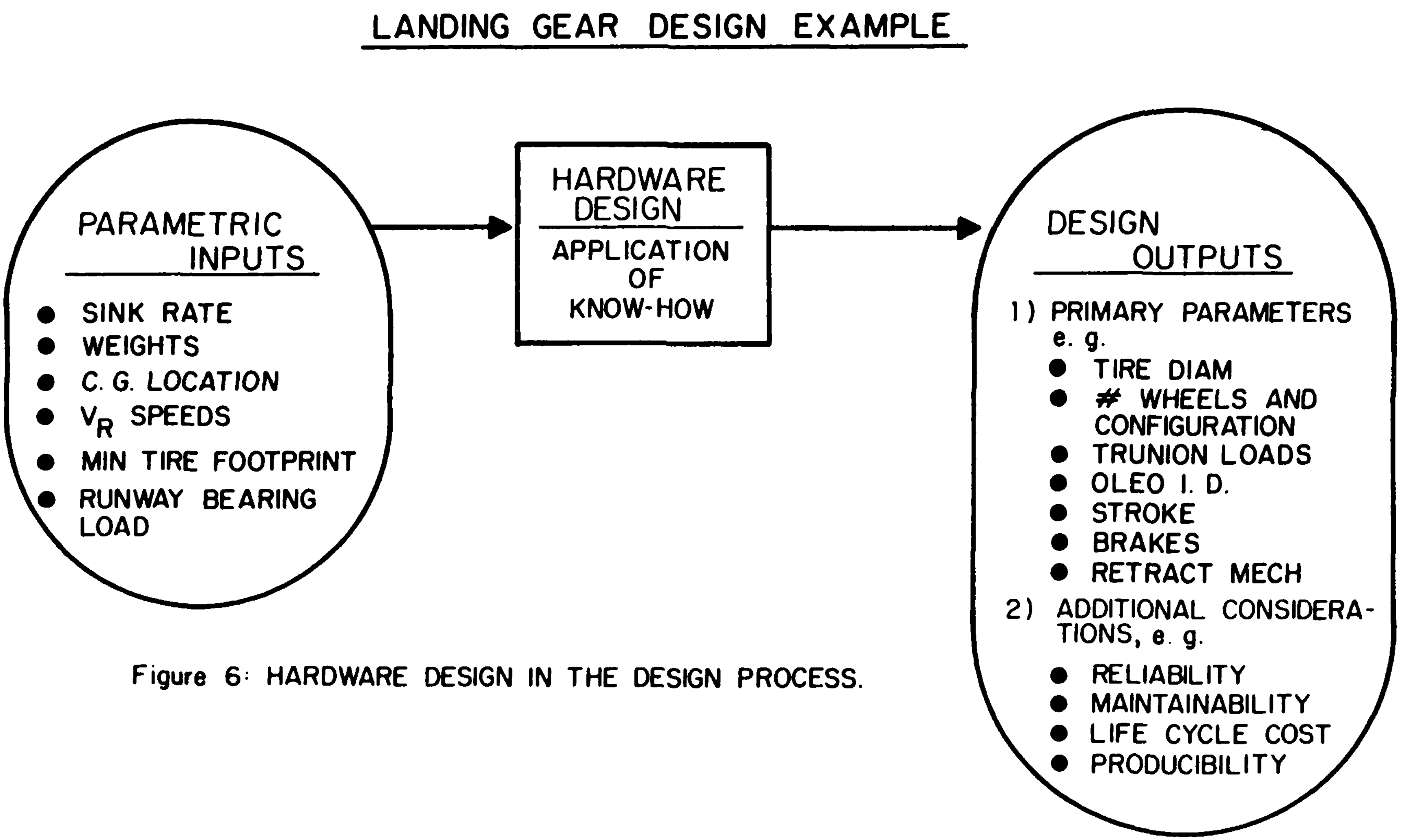


Figure 6: HARDWARE DESIGN IN THE DESIGN PROCESS.

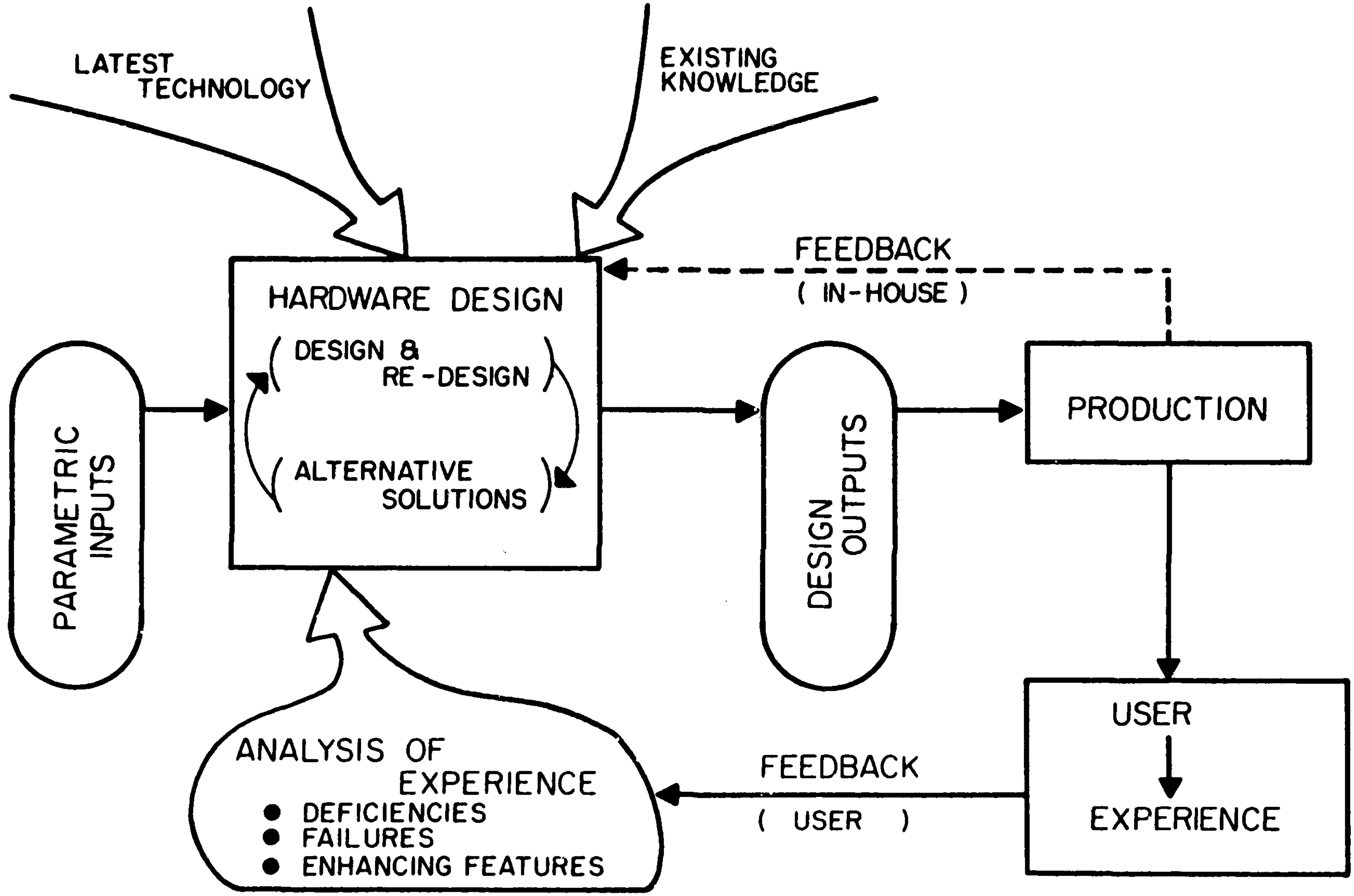


Figure 7: OPERATIONAL EXPERIENCE FEEDBACK--LINK BETWEEN USER AND HARDWARE DESIGNER.

that operational experience is not necessarily adopted in new design. [4:10]

B. VALUE OF OPERATIONAL EXPERIENCE

Build-up of design know-how in the area of operational experience not only assists contractors in achieving a competitive edge in the marketplace, but more importantly benefits the customer by potentially maximizing measures of systems effectiveness (i.e. operational readiness, aircraft availability, reliability, maintainability) and minimizing total life cycle costs. When compared to Naval Air Systems Command (NAVAIRSYSCOM) aircraft development programs, commercial aircraft development endeavors have historically pursued more vigorously the utilization of operational experience because of more cost-conscious airline customers.

In the past, systems performance has been the driving force behind military aircraft development with little or no regard for life cycle costs and systems effectiveness. This emphasis on performance often displaced proven state-of-the-art technology and operational experience for unproven advanced technology. There was little need or incentive to look back and learn from operational experiences. Penalties have been excessive operating and support costs, and unacceptable levels of operational readiness and aircraft availability in fleet squadrons.

It has not been until recent times that military aircraft design priorities have been re-directed to specifying

required levels of achievement for systems effectiveness. Most new development contracts now include incentive/penalty clauses for systems effectiveness parameters. At minimum the parameters express required levels of operational readiness, aircraft availability, and major sub-system reliability and maintainability.

Systems effectiveness parameters to be achieved by the aircraft weapons system are specified in quantitative terms. It is then the designer's responsibility to convert the specified quantitative requirements into qualitative hardware design characteristics capable of meeting or exceeding the specified requirements. To accomplish this task, designers must draw very largely on past design knowledge.

C. THE EXPERIENCE GAP

The preferred method by which previous design knowledge can be obtained is by first-hand experience from previous hardware design assignments. Frequent new development starts from post WWII until the mid 1950s provided much experience for aeronautical designers of that time. The experience build-up of that decade undoubtedly assisted many design teams in creating better alternative solutions to design problems in subsequent design efforts. Hopefully such experience also avoided repetitive mistakes of previous designs.

The most recent generation of aerospace design engineers have not had similar opportunities for obtaining such

experience build-up and resultant knowledge. The average level of design experience build-up achieved by the individual engineer is steadily declining, a result of fewer program starts and attrition of senior design engineers. Yet, emphasis since the mid-1960s for improving life cycle costs and system effectiveness compounded by increased systems complexity has given cause to achieve a higher level of experience build-up. Divergence between acquired and needed levels of design experience build-up has been expanding the experience gap, shown in Figure 8.

D. FEEDBACK FOR SHRINKING THE EXPERIENCE GAP

As early as 1971, Dr. John S. Forster, Jr., then Director of Defense Research and Engineering, strongly expressed his viewpoints to recreating and preserving design expertise in government and industry. [21:21] Little has been accomplished by the DoD over the ensuing years, in way of a unified approach to restrain the growth in the experience gap and preserve design expertise in military aircraft development programs. Nevertheless, industry long recognizing the need to find ways of obtaining operational experience, has been taking progressive steps in developing suitable experience feedback systems. [23:103]

In light of today's rapidly expanding computer information processing capabilities, computer-aided engineering design feedback systems can be made a reality. Such systems could greatly assist in shrinking the experience gap.

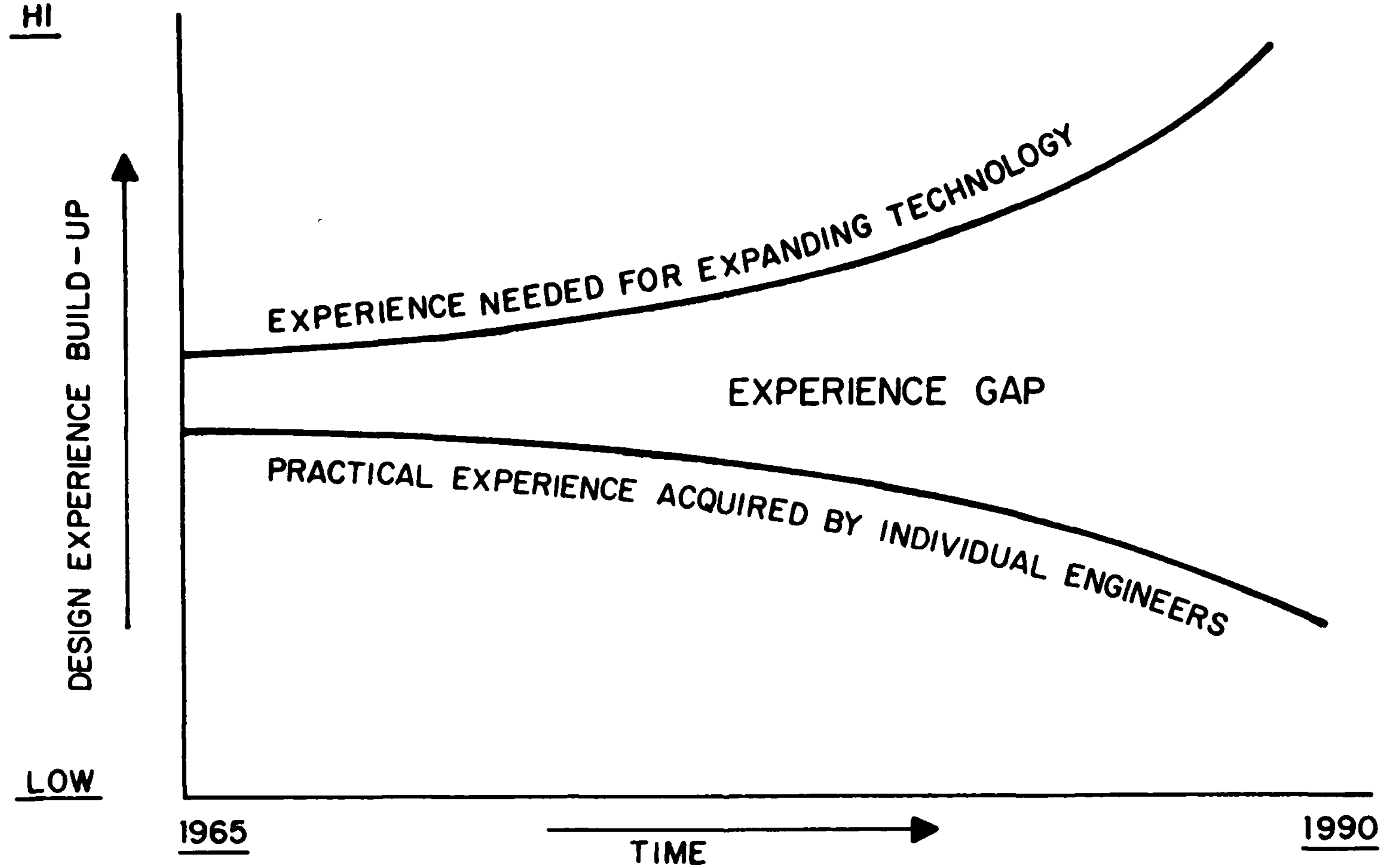


Figure 8: GROWING EXPERIENCE GAP IN AEROSPACE DESIGN.

However, to achieve maximum benefit, the systems must be formulated and developed to provide operational experience information in a timely and meaningful user language format.

IV. FEEDBACK OF OPERATIONAL EXPERIENCE IN COMMERCIAL AIR TRANSPORTATION

Apart from the past major technological breakthroughs (turbojet engine, swept wing, high-by-pass fan engine, etc.) the overall gain by the air transport industry has been achieved by a large number of relatively small improvements in numerous areas. Hence, technology advances have not necessarily been stored and used all at once in a new design, with all the attendant risks, but rather they have been incorporated gradually in successive aircraft development programs. [3:462] Many of the small improvements result from the lessons learned in daily operations. Aerospace contractors associated with the air transport industry find feedback of operational experience from airline customers essential for continued improvements in present production and new development aircraft. Figure 9 illustrates the several important information sources providing feedback from the customer (ultimate user) to the manufacturer in the commercial air transport industry. It should be noted that contractor technical information systems and field service representatives are internal or first level feedback sources, while Federal Aviation Administration (FAA) and the Air Transport Association (ATA) are external or second level sources.

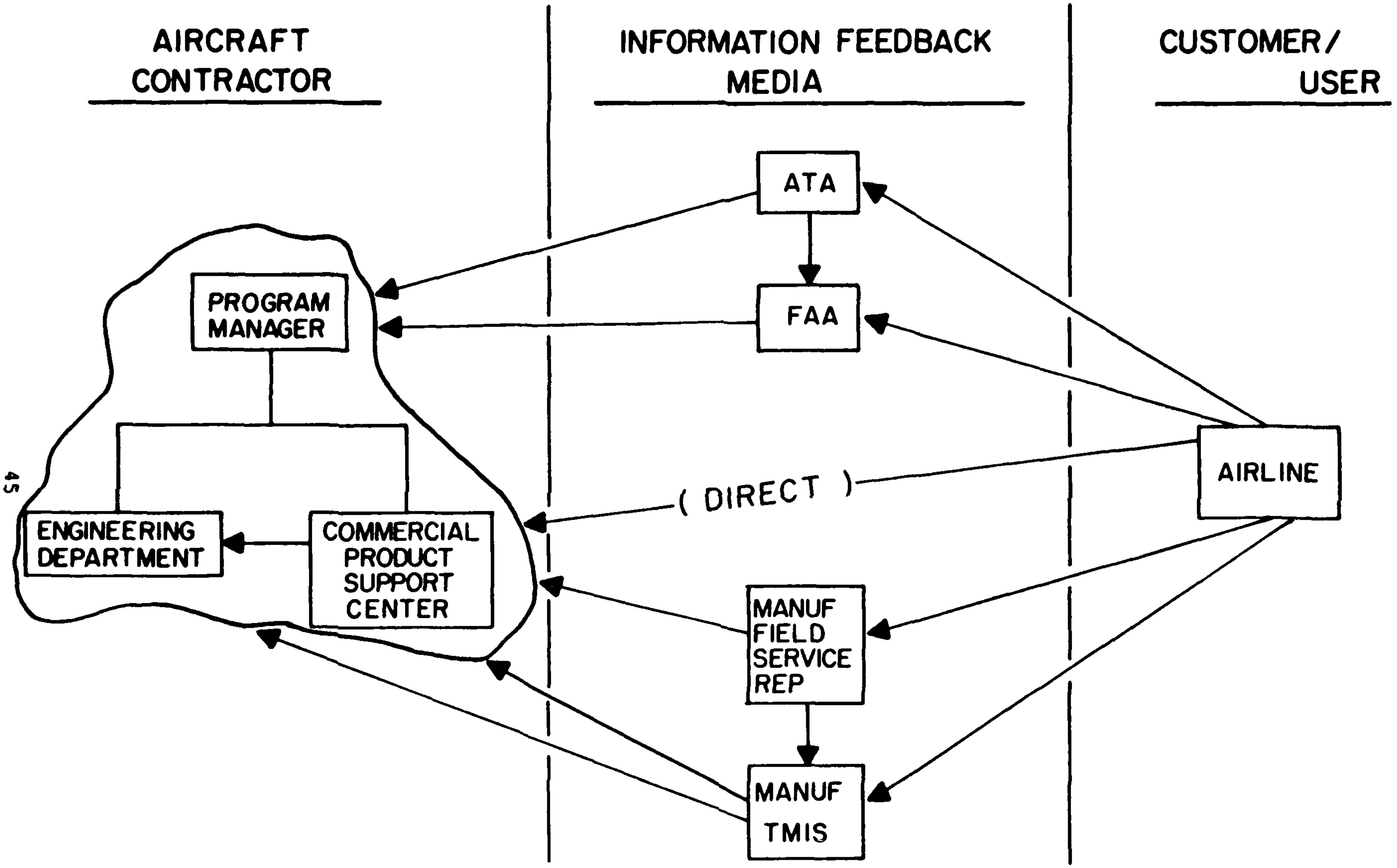


Figure 9: OPERATIONAL EXPERIENCE FEEDBACK FLOW -- IN COMMERCIAL AIR TRANSPORTATION.

A. INTERNAL OR FIRST LEVEL SOURCES

1. Management Information Systems

One method by which aircraft contractors can maintain liaison with the airline operators is via some form of a Management Information System (MIS). This is a centralized system for providing information to support current operations, future aircraft development, program management, and organizational decision-making functions.

Each of the three principal domestic transport aircraft manufacturers has its own unique system. Lockheed-California Company (LCC) will be taken as an example. Their management information system, called Operational Support Data System (OSDS), has been providing feedback information since 1969.

OSDS is essentially a closed loop information feedback system. At the time of its inception, its primary purpose was to provide visibility to program management that the L-1011 TriStar is performing to the required levels of reliability, maintainability, safety and performance standard. Responsibility for operation of the OSDS was assigned to Lockheed's Commercial Product Support Center. Functions of this center are listed in Figure 10, and include design support. Commercial reliability and maintainability responsibilities of the support center are spelled out in Lockheed's Management Directive Number 162 contained in Appendix B of this study.

TriStar L-1011

AIRLINE SUPPORT

LOCKHEED PRODUCT SUPPORT FUNCTIONS

- TECHNICAL SUPPORT
- MANUALS
  - IPC
  - MAINTENANCE
  - OVERHAUL
  - STRUCTURAL REPAIR
  - WIRING DIAGRAM
- TRAINING

- PROVISIONING
- SUPPORT CONTRACTS
- SPARES SUPPLY
- DESIGN SUPPORT
- NEW CUSTOMER PROGRAMS
- WARRANTY ADMINISTRATION

FIGURE 10: FUNCTIONS OF LOCKHEED'S COMMERCIAL PRODUCT SUPPORT CENTER

8-11-1196
July 10, 1979

A lesser priority purpose of the now ten year old OSDS was the feedback and build-up of design experience information related to the L-1011 TriStar. The current value of this information is now priceless in Lockheed's on-going TriStar product improvement programs, L-1011 derivative development programs, and preliminary design efforts for a TriStar replacement.

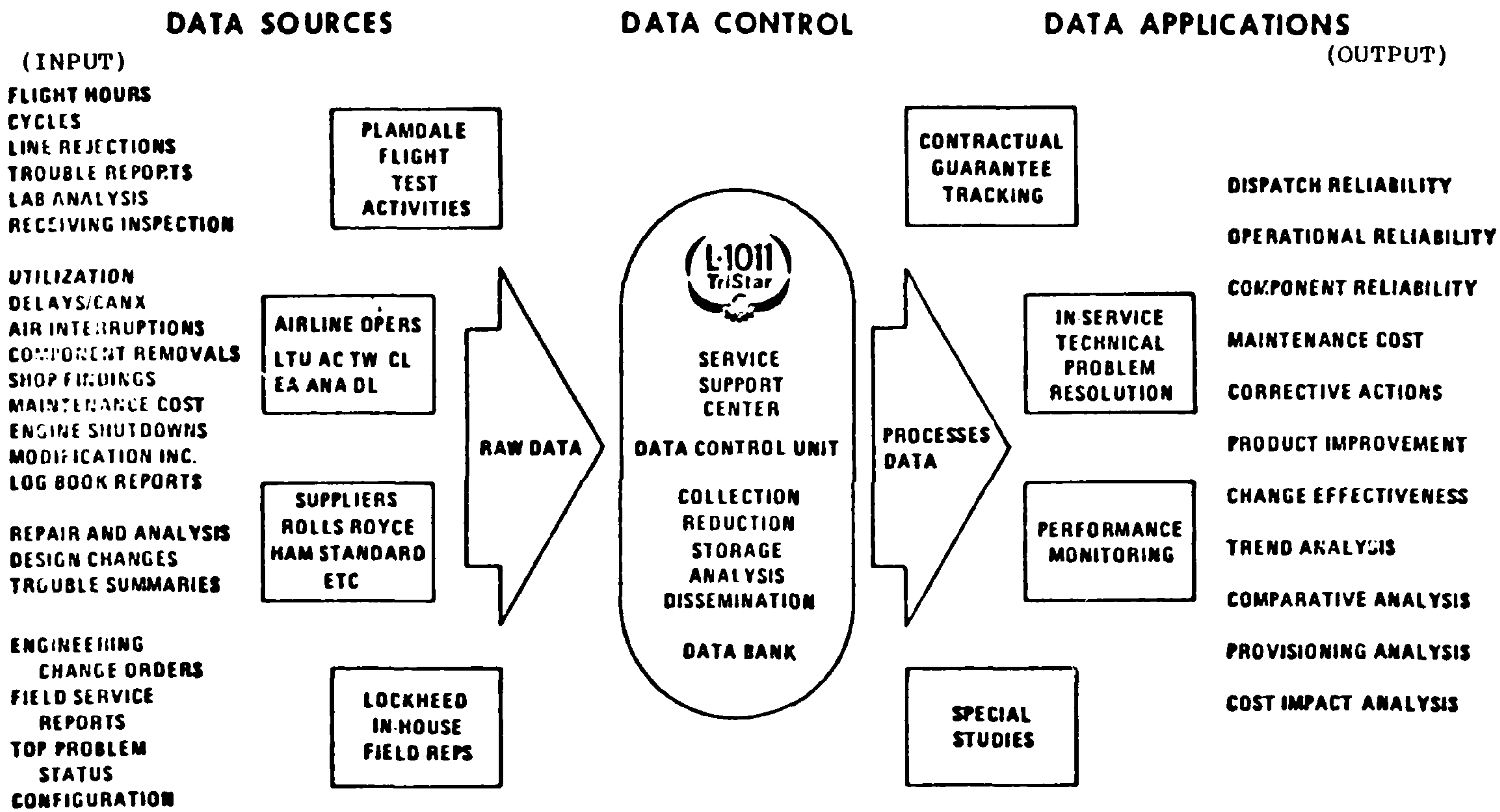
LCC employs OSDS in two ways -- in everyday operations and in technical management decision-making. Design-oriented functions are an important part of everyday operations. As defined by Ein-Dor and Segev:

> A management information system is a system for collecting, storing, retrieving and processing information that is used, or desired, by one or more managers in the performance of their duties. [6:16]

In view of this generally accepted definition of MIS, LCC's OSDS can very well be titled, "A Technical Management Information System (TMIS)".

a. Information Inputs

In the customer and contractor interface, feedback emerges from one source only -- the customer, as shown in Figure 9. When considering the user and designer interface within the respective customer and contractor organizations, feedback emerges from a multitude of sources. Sources include the contractor's test and evaluation activities, and his subcontractors and suppliers for furnished equipment and hardware. Four sources of feedback in LCC's OSDS are shown in Figure 11, under data sources.



Source: Lockheed-California Company

FIGURE 11: LOCKHEED'S OPERATIONAL SUPPORT DATA SYSTEM (OSDS)

Source data can be made available in a variety of forms, depending upon circumstances and agreements previously reached with the sources. Due to differences in reporting capabilities and differences encountered in world wide airline operations, vehicles for reporting must remain flexible. Lockheed, for example, processes every kind of input from text written on paper through automated data processing punch cards and magnetic tapes.

Standardization of source data inputs is most important in standardization of the data bank baseline. Quantitative data inputs such as aircraft utilization, departure delays, maintenance cost, and the like, require standardized measurement by all participating data sources. Failure to do so will result in an unreliable and non-usable output product. Lockheed reports that achieving uniformity in reporting by all data feedback sources has been and continues to be the greatest difficulty in their OSDS.

b. Information Processing

The major portion of a management information system is concerned with collecting, reducing, storing, retrieving, analyzing and disseminating information. The aggregate of these activities can be termed information processing. Lockheed chooses to call it data control.

Data control within Lockheed's OSDS is also the responsibility of the Commercial Product Support Center. As shown in Figure 11, the elements of data control conform to the intent of information processing described for a MIS.

c. Output Products

The type and number of MIS output products are completely variable and limited only by source data and processing software programs capabilities. However, if the MIS is to be successful, the products must be compatible with the needs and requirements of the users.

The output from Lockheed's OSDS comes in various forms and covers a variety of subjects in reports tailored to meet the requirements of L-1011 TriStar management tasks. The output reports listed in Figure 11 are typical of the periodic reports processed by OSDS. A representative sample of output reports related to operational experience is contained in Appendix C.

d. Information Applications

Among the criteria for determining a successful from an unsuccessful MIS is how the output products are applied. One condition for a successful MIS is that it be applied to major problems of an organization. [6 :19-20]

Broadly speaking, OSDS programs provide the necessary information for three areas of major concern: First, keeping upper and operating management informed of program performance status; second, establishing priorities for directing product improvement; and third, providing technical groups (product support and engineering) design experience with fielded hardware. It is the third area that is of concern in this study.

Lockheed's OSDS finds definite application in monitoring design deficiencies or problem areas as they show up in airline operation. When a transport aircraft is unable to meet a scheduled departure for technical reasons, it is essential to have immediate feedback of engineering information and to follow up with remedial action. The corresponding organization is provided by Product Support. It is based on availability of operational experience. [22:11]

A most important aircraft performance parameter for airline operations is dispatch reliability. Dispatch delays in excess of 15 minutes or flight cancellation are closely monitored as to cause. Aircraft systems contributing to dispatch delays or cancellations are monitored and reported by OSDS. Standard reports, as shown in Figure 12, rank system contribution by percent of total. Lockheed's effort to improve L-1011 dispatch reliability serves as an example of OSDS design support application in both special studies and tackling in-service technical problems.

Using OSDS data bank information, subsequent special studies are undertaken to define the problem and identify the problem component. After the component has been identified, in-depth and detailed studies follow to determine component failure item and cause of failure. These data and information are then transferred from the OSDS operations group to program engineering. Engineering determines the "why" of failure and develops a new or improved design for inclusion into existing and future programs.

TriStar L-1011

0105010

FLEET TECHNICAL DELAYS AND CANCELLATIONS

7-13-79

JUNE 1979

RANK	ATA	SYSTEM	PERCENT OF TOTAL
1	71/72	POWER PLANT	9.7
2	27	FLIGHT CONTROLS	9.1
3	32	LANDING GEAR	7.9
4	05	AIRCRAFT GENERAL	7.7
5	52	DOORS	7.4
6	24	ELECTRICAL POWER	5.8
7	29	HYDRAULIC POWER	5.8
8	73	ENG FUEL & CONTROL	5.5
9	21	AIR CONDITIONING	4.0
10	31/34	INSTR/NAV	3.6
11	78	ENGINE EXHAUST	3.6
12	00	GSE	3.1
13	22	AUTO FLIGHT	3.1
14	28	FUEL	3.1
15	36	PNEUMATIC	2.9
16	77	ENGINE INDICATING	2.3
17	80	STARTING	2.1
18	23	COMMUNICATIONS	2.0
19	51,53-55,57	STRUCTURES	2.0
20	38	WATER AND WASTE	1.9
21	33	LIGHTS	1.3
22	75	ENGINE AIR	1.2
23	49	APU	1.0
24	79	ENGINE OIL	0.9
25	30	ICE & RAIN PROTECT.	0.7
26	25	EQUIP/FURNISHINGS	0.5
27	56	WINDOWS	0.5
28	76	ENGINE CONTROLS	0.5
29	26	FIRE PROTECTION	0.3
30	35	OXYGEN	0.3
31	74	ENGINE IGNITION	0.2

FIGURE 12: AIRCRAFT SYSTEM CONTRIBUTION TO DISPATCH DELAYS AND CANCELLATIONS

2. Field Service Representatives

Since the days of the Wright Flyer, a vital link between the contractor and his customers has been the Field Service Representative, often better known as the "Tech-Rep." In the early days, Tech-Reps were just what the name implied -- Technical Representatives. However, in today's environment, they provide a host of administrative as well as technical services. Services are rendered to both their employer and customer.

The vast majority of data inputs for technical management information systems, such as Lockheed's Operational Support Data System, are generated by Field Service Representatives. L-1011 TriStar field reports generated for inclusion in the OSDS are found in Table I. Volume of communications traffic associated with these reports from 19 field offices (11 American and 8 International) is shown in Figure 13.

Field Service Representatives are also the contractor's eyes and ears. Aside from the mundane tasks of providing technical and administrative assistance to both their employer and customer, Field Service Representatives are in a position to compile competitive business intelligence.

The intelligence function in business is recognized by many competitive corporations as one of the keys for successful strategic planning and decision making by top management. [26:2] Intelligence gathering by Field Service Representatives accounts for only a small segment of business

TriStar L-1011

FIELD SERVICE REPORTS/BRIEFINGS

- FIELD REPORTS
  - DAILY WIRES – INITIATED AT DELIVERY OF FIRST AIRCRAFT FOR 6-12 MONTHS
  - DELAY WIRES – SENT DAILY (M-F) WITH WEEKEND UPDATE ON MONDAYS
  - PERFORMANCE REPORT – AIRCRAFT HOURS AND LANDINGS
  - SIGNIFICANT TECHNICAL PROBLEMS – SUBMITTED WEEKLY
  - ACTIVITY REPORTS – SUBMITTED WEEKLY
  - SERVICE BULLETIN STATUS – SUBMITTED BI-MONTHLY
  - COMMERCIAL SERVICE TROUBLE REPORTS (CSTR) – SUBMITTED ON ALL WARRANTY CLAIMS AND AS NECESSARY TO REPORT SIGNIFICANT TECHNICAL DISCREPANCIES
  - INCIDENT REPORTS – SUBMITTED FOR ALL INCIDENTS INVOLVING POTENTIAL OR ACTUAL HAZARD TO PASSENGER, CREW OR AIRCRAFT
  - PUBLICATION CHANGE REQUESTS (PCR) – SUBMITTED TO SUGGEST CHANGES TO TECHNICAL PUBLICATIONS AND REPORT DISCREPANCIES. ALSO USED TO PROVIDE FEEDBACK ON TRAINING MATERIALS
  - SCHEDULE AND ROUTING – SUBMITTED WHEN AIRLINE SCHEDULE AND ROUTING OF AIRCRAFT CHANGES ARE IMPLEMENTED
  - SURVEYS – SUBMITTED ON SPECIFIC PROBLEM AND DIRECTED BY PRODUCT SUPPORT CENTER
- FIELD BRIEFINGS
  - RESIDENT SERVICE MANAGERS CONFERENCE – HELD ANNUALLY
  - FREQUENT VISITS TO FIELD OFFICES BY PRODUCT SUPPORT MANAGERS

TABLE I

LOCKHEED COMMERCIAL FIELD SERVICE REPRESENTATIVE REPORTS

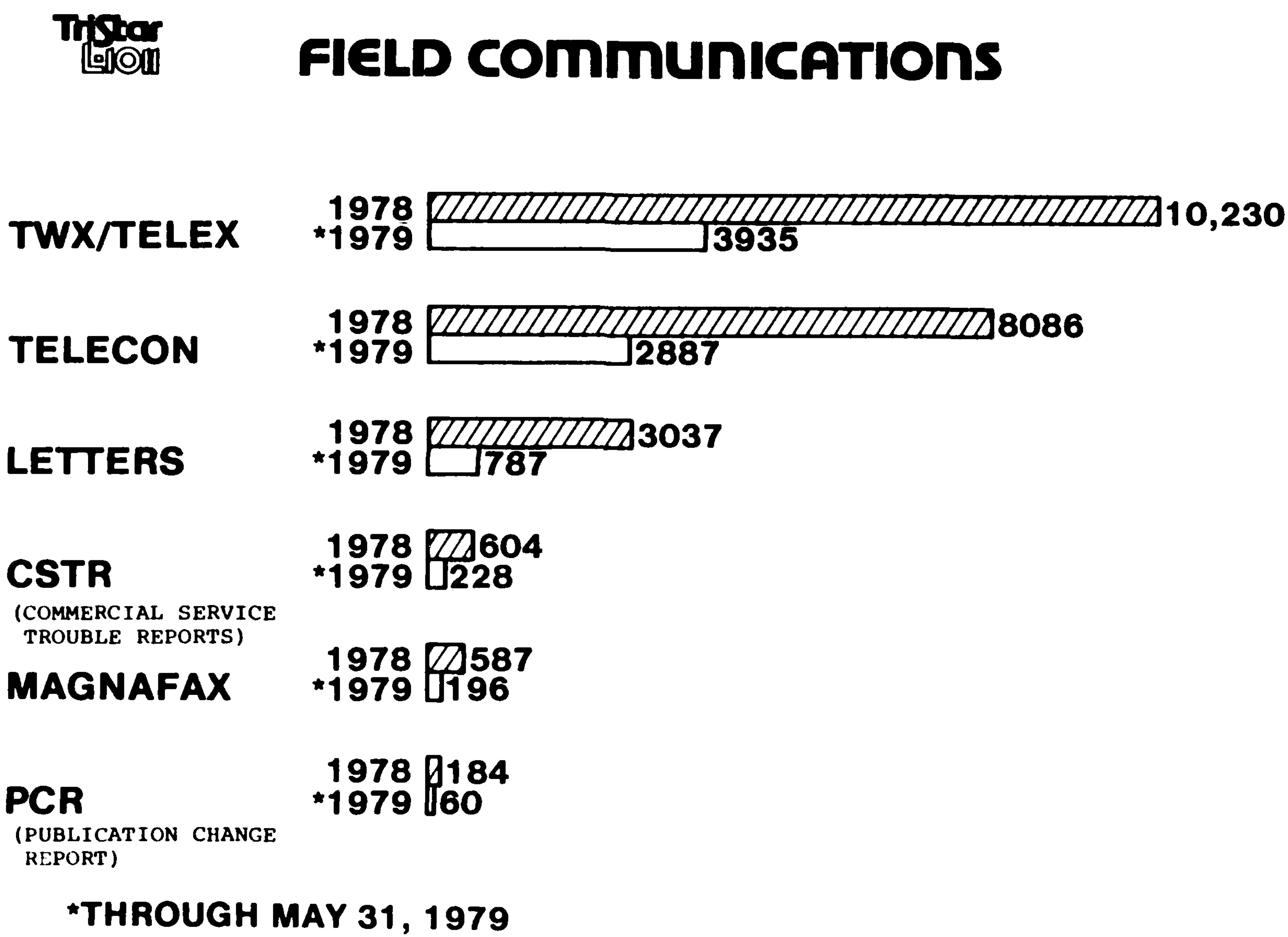


FIGURE 13: FREQUENCY OF REPORTING BY LOCKHEED COMMERCIAL FIELD SERVICE REPRESENTATIVES

intelligence assemination, and should be considered confined to areas of technical interest.

Areas of technical interest include monitoring the performance characteristics of competitor equipment, observing airline operator likes and dislikes in both equipment being represented and competitor equipment, and identifying desirable features in operator's future equipment needs. Feedback and utilization of such intelligence can be of great assistance in directing design strategy to be taken in new aircraft developments, and in tailoring future equipment to the airline operator needs and environment.

B. EXTERNAL OR SECOND LEVEL SOURCES

1. Air Transport Association of America (ATA)

The ATA is a membership organization serving the many needs of U.S. flag air carriers. While ATA's emphasis in support of air carrier needs is on federal regulatory affairs, it also provides engineering and maintenance services. Of interest are its engineering and maintenance activities keyed to aircraft design standardization in areas of ground servicing and maintenance, technical information index standardization, technical problems conferences, and developing the industry's position on Federal Aviation Administration proposed rule making. The unified position on technical issues voiced by the ATA for the air transport industry has definite influential impact on federal air regulation rule making and contractor response to in-service equipment

problems as well as future derivative or next generation aircraft design characteristics and features.

The feedback of design or technical information from the airline operators to the contractor's design engineering team via the ATA is shown in Figure 9 and is external to normal channels employed by the contractor. Information feedback of this type is primarily generated by "as the need arises" or "on-exception" basis.

2. Federal Aviation Administration (FAA)

The Federal Aviation Administration (FAA), an agency of the Department of Transportation, has comprehensive authority over air safety and control over all U.S. airspace. FAA's technical responsibilities in the air transport industry include: establishing and maintaining Federal Air Regulations related to requirements for aircraft design and construction; aircraft airworthiness certification; monitoring health of aircraft fleets; approving major engineering changes and alterations to civil aircraft; and issuing airworthiness directives for mandating action required by contractors and operators for sustaining aircraft airworthiness. FAA air-carrier field office activities at airline main-base of operations and mandatory airline reporting of equipment defects or failures adversely affecting flight safety are the primary sources of information feedback.

The flow of information, like that of the ATA, is external to the regular or normal channels employed by the

contractor and it too is predicated on "as the need arises" or an "on-exception" basis.

V. FEEDBACK OF OPERATIONAL EXPERIENCE IN NAVAL AVIATION

Excluding military avionics systems, technology advances in applied military aerospace technology have historically been the "pathfinders" for the entire aerospace industry. In the past, the push for superior preformance requirements in military programs contrasted sharply with life-cycle costs and systems effectiveness objectives of the air transport industry. Changes in Naval Air Systems Command (NAVAIRSYSCOM) acquisition policy have placed increased emphasis on life-cycle costs and systems effectiveness.

Despite efforts to improve weapon system acquisition efficiency and effectiveness through a pyramid of ever-changing program management policies and directives, the single most dominant factor governing life-cycle costs and systems effectiveness relates to operational experience. A clearly established system for feeding back operational experience to the designer can greatly assist aircraft contractors in achieving NAVAIRSYSCOM aircraft design objectives.

A. CONTRACTOR INFORMATION FEEDBACK SOURCES

Figure 14 portrays the primary sources of feedback from the Navy user to the prime contractor. Although information feedback sources closely resemble sources in commercial programs shown in Figure 9, vast differences exist in

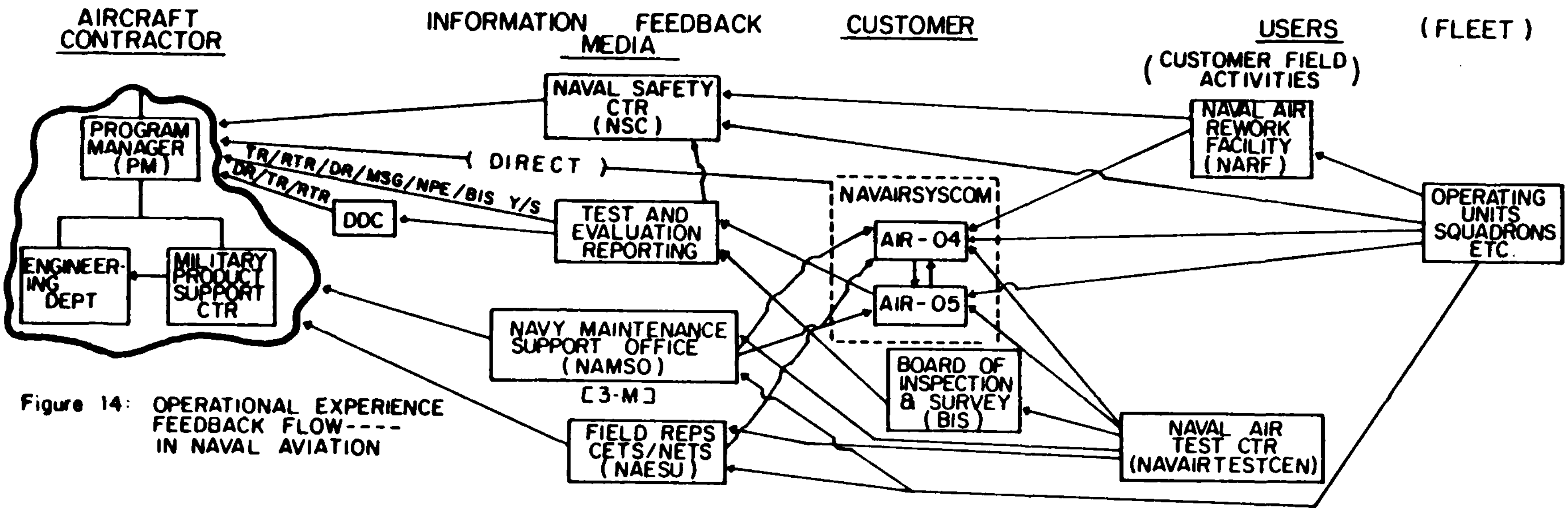


Figure 14: OPERATIONAL EXPERIENCE FEEDBACK FLOW---- IN NAVAL AVIATION

information flow. The differences are largely a result of decentralized information collection, storage, retrieval, analysis and application.

In military aircraft programs, little emphasis has been placed on systematic evaluation of experience until recently. There are several reasons for this. First, with roughly 10 major aircraft manufacturers (fixed and rotor wing) competing for less than half as many development contracts in a given 10 year span, there is only remote probability in favor of landing a development contract as prime contractor. Under such odds, little incentive exists to develop and maintain a feedback capability and data bank, especially when sustaining engineering funds are not provided by NAVAIRSYSCOM. Contrary to the airline operator's farsighted procurement policy, military services depend on yearly approvals of a Congressional budget. This has had an adverse effect on the long-range funding required for a feedback system. There are, however, signs for improvements in the future. A second reason stems from industry competition differences between military and commercial aircraft procurement. Compared to military sole-source procurements, the airlines are at liberty to choose from a variety of similar and competing aircraft. To hopefully gain a competitive edge in commercial programs, a contractor will take full advantage of operational experience from fielded equipment.

From Figure 14, the only internal or first level feedback source available to the contractor is through his field service representatives. Three of the remaining four sources are external or second level and one source is direct from NAVAIRSYSCOM.

1. <u>Internal or First Level Sources</u>

Since the fledgling days of military aviation, contractor field service representatives have provided the armed forces invaluable technical services. Their technical assistance to improve the technical expertise of military maintainers has had a positive impact on achieving operational readiness goals and is considered one of their primary roles. Another primary role pertains to monitoring performance and systems effectiveness of the aircraft weapon system they represent.

Significant technical problems or discrepancies encountered are reported via numerous modes of communication. Contractor utilization of such feedback data is usually confined to resolving current product problems and product improvement, whereas in commercial programs, such data would also be utilized in future derivative or new development projects.

In the late 1960s, the Naval Aviation Engineering Services Unit (NAESU) sought self-sufficiency for the Navy during the latter phase of the aircraft life-cycle coupled with the desire to reduce expenditures for contractor sustaining engineering. The result was creation of the

Contractor Engineering Technical Services (CETS) and Navy Engineering Technical Services (NETS) programs.

Under the CETS/NETS concept, contractor field-service representatives assigned to fleet operating units are fewer in number and are providing technical services for a much shorter period of time. What was once a "cradle-to-grave" field-service support program by the contractor has been reduced to only a fraction of the weapons system life cycle.

The effect on the contractors has been a sizable reduction in feedback of internally generated or first level design experience information. The end result is undoubtedly contributing to the problem of maintaining contractor design team capability.

2. <u>External or Second Level Sources</u>

a. Navy Maintenance Support Office

An excellent source of operational experience data is provided by the Navy Maintenance Support Office (NAMSO) of the Fleet Material Support Office (FMSO). Designed, developed and operated to provide maintenance and maintenance support data to all levels of Navy management, NAMSO's wealth of analytical and statistical products are available to all authorized research and development contractors.

Shown in Figure 14 is NAMSO's fit into the feedback flow pattern, between the user and contractor. Its input, processing and output functions are similar to Lockheed's Operational Support Data System (OSDS) discussed in Section IV.

(1) Information Inputs. Information feedback for NAMSO emerges from basically two sources -- fleet aviation activities and NAVAIRSYSCOM research, development, test and evaluation field activities. Information is accumulated by the Maintenance Data Collection Subsystem (MDCS) which is an integral part of the Navy Maintenance, Material and Manpower Management System, more commonly known as the Navy 3-M system. The 3-M system is sponsored by the Chief of Naval Operations (CNO) and technically supported by the Chief of Naval Material and the Naval Air Systems Command.

Source data is made available only in the type and format previously approved by CNO in OPNAV Instruction 4790.2. Changes in data type or format desired by MSO must be approved by CNO. The rather inflexible system does, however, have the advantage of being a stabilized and standardized Navy-wide computerized data baseline. The problem of data reduction to achieve a standardized data base as experienced by commercial programs is totally eliminated in the 3-M system.

Types of quantitative source data reported by the 3-M system and collected by MDCS, applicable to operational experience, were found to be almost identical to Lockheed's commercial data source inputs for their OSDS listed in Figure 11. Such 3-M data include:

-- MDR (Maintenance Data Reporting);

-- MR (Material Reporting); and

-- ASD (Aircraft Statistical Data) reporting.

(2) Information Processing. Information processing of 3-M data by NAMSO is that typical of most information processing activities -- storing, retrieving, analyzing and disseminating information.

(3) Output Products. NAMSO output products are numerous and users of the numerous products are many. The products take the form of standard reports and summaries, and special requests. Products of interest to both the contractors and the NAVAIRSYSCOM systems engineering group and related to aircraft weapon system design experience are contained in Appendix D.

(4) Information Application. NAMSO output products serve a host of applications. Similar to commercial program Technical Management Information Systems (TMIS), NAMSO serves contractor and Navy management needs in three broad areas: tracking weapon system performance trends in terms of readiness and utilization; establishing priorities for service problem and deficiency correction; and providing technical groups information for utilization in product improvement and new design development programs. Unlike commercial program information systems, which are designed and operated solely for parent company application, NAMSO serves the entire military aircraft manufacturing industry and naval aviation management structure.

NAMSO output products, quantitative and statistical in nature, find extensive application in the

area of weapon system effectiveness. The recent Chief of Naval Material and Naval Air Systems Command push to bring about increased operational readiness and reduced life cycle cost in Naval aircraft acquisition has given cause to improve system reliability and maintainability (R&M). In response to this push, NAVAIRSYSCOM and aircraft contractors have looked to NAMSO for historical statistical data such that R&M requirements and allocations can be better predicted during the early phases of the acquisition process.

b. Test and Evaluation

Test and Evaluation (T&E) is a vital function in aircraft weapon system acquisition. Starting with initial research and development, T&E is an integral and continuing part of the acquisition process. Essentially, the purpose of T&E is a determination of the suitability of hardware for service use. If the hardware functions in a technically acceptable manner and if the hardware meets the specified operational performance requirements the hardware is considered suitable for service use. [16:27] Test and evaluation identifies design deficiencies and enhancing characteristics. Thus, it provides feedback to design teams and program management for the contractor and Navy alike.

(1) <u>The Process</u>. Test and evaluation of a typical current generation tactical aircraft is a long and tedious process, often spanning six or more years. The process begins shortly after the first flight with the first of several contractor demonstrations, called Navy Preliminary

Evaluations (NPE). The last NPE is conducted just prior to the Board of Inspection and Survey (BIS) trials.

The purpose of an NPE is to: [11:19]

-- Determine at the earliest possible opportunity the combat potential and gross deficiencies of the aircraft and its systems, and

-- Allow early correction of deficiencies.

Following the NPEs, the BIS trials are commenced to determine service suitability and contractor specification conformance in production configured aircraft. All discrepancies reported during the NPEs and BIS trials must be corrected or otherwise resolved before the aircraft is considered service suitable.

Follow-on T&E is conducted after the aircraft is delivered to fleet operating activities. The majority of this effort is confined to engineering change proposal actions, accelerated service testing, assistance in derivative development, and operating problems encountered by fleet activities.

(2) Reporting Results. T&E reporting provides feedback as shown in Figure 14. The Naval Air Test Center (NAVAIRTESTCEN), chartered as the Navy's field activity for aircraft weapons system T&E, utilizes five basic report types for reporting T&E results. The reports include:

-- BIS Yellow Sheet (Y/S);

-- Deficiency Report (DR);

-- Formal Technical Report (TR);

-- Report of Test Results (RTR); and

-- Message Report.

A detailed description of these reports is found in Table II. With the exception of the BIS Yellow Sheet and NAVAIRTESTCEN Deficiency Report which are confined to deficiency reporting only, aircraft enhancing characteristics as well as deficiencies are reported.

(a) Enhancing Characteristics. Those characteristics of the aircraft or equipment which significantly enhance its operational use or technical capability are numerated in the report. The characteristics listed emphasize the significant strong points or capabilities and provide the contractor and Navy program manager with the good side of the picture. More importantly for design experience information feedback, it acknowledges outstanding characteristics which should be incorporated into future new development program designs and specifications.

(b) Deficiency Classification. Deficiencies identified during the course of T&E are fully qualified in the text of the applicable T&E report. In order to differentiate a more serious deficiency from a less serious one, the Naval Air Test Center classifies each deficiency. Deficiencies are placed into one of the following three

TABLE II

TYPES OF NAVAL AIR TEST CENTER T&E REPORTS

1. BIS Yellow Sheet (Y/S). This is the means for reporting deficiencies noted during Board of Inspection and Survey (BIS) trials. The report by its nature requires rapid transfer of information, and as such, each deficiency is reported separately on its own report format.

2. Deficiency Report (DR). This is the means for reporting deficiencies noted during Navy preliminary evaluations (NPE). The report by its nature requires rapid transfer of information, and as such, each deficiency is reported separately on its own report.

3. Formal Technical Report (TR). This is the primary means for documenting the results of project work. This report is used when the reported results will be significant for a long period of time, will be widely distributed (i.e. Defense Documentation Center) or have other important aspects which require the report to have lasting value.

4. Report of Test Results (RTR). This is the means for reporting information which is limited in scope, application or time. It is usually used for reporting interim results of any project when relatively short periods of time or minor sections of test are involved.

5. Message Report. This is the means for reporting information that is of an urgent nature. It is used for reporting results of limited scope evaluation phases or preliminary summary results of large scope evaluations/ evaluation phases.

Source: Naval Air Test Center

TABLE III

CLASSIFICATION OF DEFICIENCIES BY THE NAVAL AIR TEST CENTER

1. Part I

   a. Airworthiness of the aircraft.

   b. The ability of the aircraft (or piece of equipment) to accomplish its primary or secondary mission (or intended use).

   c. The effectiveness of the crew as an essential subsystem.

   d. The safety of the crew or the integrity of an essential subsystem. In this regard, a real likelihood of injury or damage must exist. Remote possibilities or unlikely sequences of events shall not be used as a basis for safety items.

A Part I deficiency is the most serious category in which a deficiency can be placed. It indicates an unsatisfactory characteristic. The criteria to be used in determining whether or not a deficiency is a Part I deficiency is to ask the question, can the aircraft or piece of equipment accomplish its mission with a satisfactory degree of safety and effectiveness? If not, then a Part I deficiency exists.

2. Part II indicates a deficiency of lesser severity than a Part I which does not substantially reduce the ability of the aircraft or piece of equipment to accomplish its primary or secondary mission, but the correction of which will result in significant improvement in the effectiveness, reliability, maintainability, or safety of the aircraft or equipment. A Part II deficiency is a deficiency which either degrades the capabilities of the equipment or requires significant operator compensation to achieve the desired level of performance; however, the aircraft or equipment being tested is still capable of accomplishing its mission with a satisfactory degree of safety and effectiveness.

3. Part III indicates a deficiency which is minor or slightly unpleasant or appears too impractical or uneconomical to correct in this model, but should be avoided in future designs.

Source: Naval Air Test Center

categories: Part I, Part II, or Part III. Table III outlines the criteria for deficiency classification.

A Part I deficiency, the most serious of the three must be corrected as early as "prior to further flying" or as late as "soon as possible, but not to interfere with development." A Part II deficiency is to be corrected "as soon as practicable." Lastly, the least serious Part III deficiency is "to be avoided in future designs." [14:III-27]

A breakdown of deficiencies reported in previous NPEs and BIS trials pertaining to recent aircraft development programs is contained in Table IV. By far, the most frequently reported deficiency is classified as Part II.

(3) <u>Report Release and Distribution</u>. Release and distribution of NAVAIRTESTCEN and BIS reports is limited to U.S. government agencies only. Requests for reports from other interested parties must be directed to either the NAVAIRTESTCEN or the Sub-Board of Inspection and Survey. Normal distribution of reports will include:

- Cognizant NAVAIRSYSCOM Program Manager for Acquisition (PMA);
- Cognizant NAVAIRSYSCOM Class Desk Officer;
- Cognizant NAVPRO/DCAS/AFPRO; and
- Applicable NAVAIRSYSCOM Systems Engineering Technical Division.

Distribution of reports is accomplished

TABLE IV

DEFICIENCIES REPORTED ON PREVIOUS AIRCRAFT DURING NPE AND BIS TRIALS

DEFICIENCY CLASSIFICATION
(PART)

AIRCRAFT PROGRAM	I quantity	I % of total	II quantity	II % of total	III quantity	III % of total	TOTAL DEFICIENCIES
A-7A	120	31	255	66	13	3	388
A-7B	58	50	43	37	15	13	116
A-7E	66	30	133	61	20	9	219
F-14	230	25	547	59	147	16	924
S-3A	157	17	691	74	91	9	939
TA-7C	20	20	59	59	21	21	100

Source: Sub-Board of Inspection and Survey, Patuxent River, MD.

via hard-copy. Only the Defense Documentation Center (DDC) makes copy available in microfiche, and the reports available are limited to NAVAIRTESTCEN DRs, TRs, and RTRs.

c. Naval Safety Center

While not playing a major role in volume of experience feedback, the Safety Center does provide vital feedback related to flight and maintenance operations safety. Similar to the reporting requirements imposed upon the commercial airlines by the Federal Avaiation Administration, information input into the Safety Center is in the form of mandatory reporting by fleet operating units. Such inputs include safety unsatisfactory material/condition reports, aircraft incident reports, aircraft accident reports, and the like.

The Safety Center does their own in-house data compilation, processing, and analysis. Many of the output products assist NAVAIRSYSCOM and contractor design teams in the elimination of undesirable safety characteristics from existing aircraft systems and future new development designs.

d. Direct Reporting by NAVAIRSYSCOMHQ

Yet another source of external or second level information is made available to the prime contractors. The Program Management (PM) Office and the cognizant technical divisions are sources in the NAVAIRSYSCOMHQ reporting directly to the contractor. See Figure 14.

During the full scale engineering development phase of aircraft weapon system acquisition, several events take place under the jurisdiction of the PM that are of significant value to contractor design teams. These events include the full-scale engineering mock-up review, maintenance mock-up review, engineering design reviews and integrated logistic support management team meetings. The objectives of these efforts are two-fold: First, to identify design suitability problem areas as early as possible so immediate corrective action will minimize the adverse impact of cost, schedule and weight; and second, with the combined efforts of Navy and contractor supportability personnel, to develop the best possible fleet deployment support package.

After the aircraft enters production and is deployed with fleet operating units, a Naval Air Rework Facility (NARF) is assigned as the cognizant Field Activity (CFA) for engineering support of the aircraft. From that time on, until the aircraft is retired from service, the NARF and aircraft contractor can be expected to have intensive engineering ties. Engineering investigations, product improvements and service life extension programs require in-depth engineering study. Engineering studies of this type provide a wealth of invaluable information.

B. RDT&E FEEDBACK LOOP ACTION GENERATION SYSTEM

1. Background

NAVAIRTESTCEN Deficiency Reports (DR), Board of Inspection and Survey (BIS) Yellow Sheets (Y/S), and other

T&E reports discussed previously are the official means by which aircraft design deficiencies, specification violations and/or failures in equipment are identified. Traditionally, these reports have been used by cognizant NAVAIRSYSCOM and contractor program management personnel for resolving serious deficiencies associated with the specific weapon system undergoing T&E. The reported deficiencies and their solutions are generally confined to the program manager and his technical staff. The "lessons learned" are seldom applied to new development programs or made available to industry design teams as feedback for previous design experience.

Recognizing the opportunity to expand the potential utilization of T&E deficiency data, the Air Crew Systems Division (AIR-531) of NAVAIRSYSCOM launched a program in 1974 to develop a mechanized BIS Y/S tracking system related to air crew aspects of aircraft weapon systems. Among the advantages offered by the system are: [13:4]

- -- Greater consistency in the processing and application of Y/S data;
- -- Prediction of potential problems in aircraft weapon systems entering development; and
- -- Identification of technology problems for input into the R&D and training communities.

A follow-on effort, the RDT&E Feedback Loop Action Generation System (FLAGS) was undertaken in 1976 to expand and refine the BIS Y/S tracking system. As a result, FLAGS is capable of providing deficiency status reports, narrative

summary reports, statistical compilations, and the correlation of problem areas common to all fixed and rotary wing aircraft weapon systems.

2. System Objectives

FLAGS has been designed to facilitate the storage and processing of statistical (quantitative) and narrative (qualitative) information. Most important in this area is the system's capability to store and process aircraft system, subsystem, and component deficiency data resulting from mock-up reviews, design reviews, maintenance mock-up reviews, Navy Preliminary Evaluation (NPE), Board of Inspection and Survey (BIS) trials and Service Life Extension Program (SLEP) engineering investigations.

The aggregate of these individual technical informations under one system (a NAVAIR corporate memory for previous design experience) and the ability to easily retrieve user information, has satisfied most of the FLAGS objectives. Those objectives thought to have significance related to identifying and applying previous design experience are listed in Table V.

3. Information Retrieval

Retrieval of information from the FLAGS data base is limited only by the amount and the type of information stored in the data base. A simplified flow from user data query to output product is shown in Figure 15.

Information retrieval is initiated by completing a retrieval request form using applicable FLAGS coding sheets

TABLE V

OBJECTIVES OF THE FEEDBACK LOOP ACTION GENERATION SYSTEM (FLAGS)

1. Providing rapid retrieval of NPE/BIS deficiency data in simple format.

2. Printing out selective, detailed deficiency reports to facilitate specific management decisions.

3. Indicating "avoid in future design" deficiencies.

4. Associating T&E deficiency data rapidly with Mil-Specs/ Stds for updates and follow-on buys.

4. Identifying complex, recurring deficiencies for research and technology assistance.

6. Contributing to R&D requirements definition.

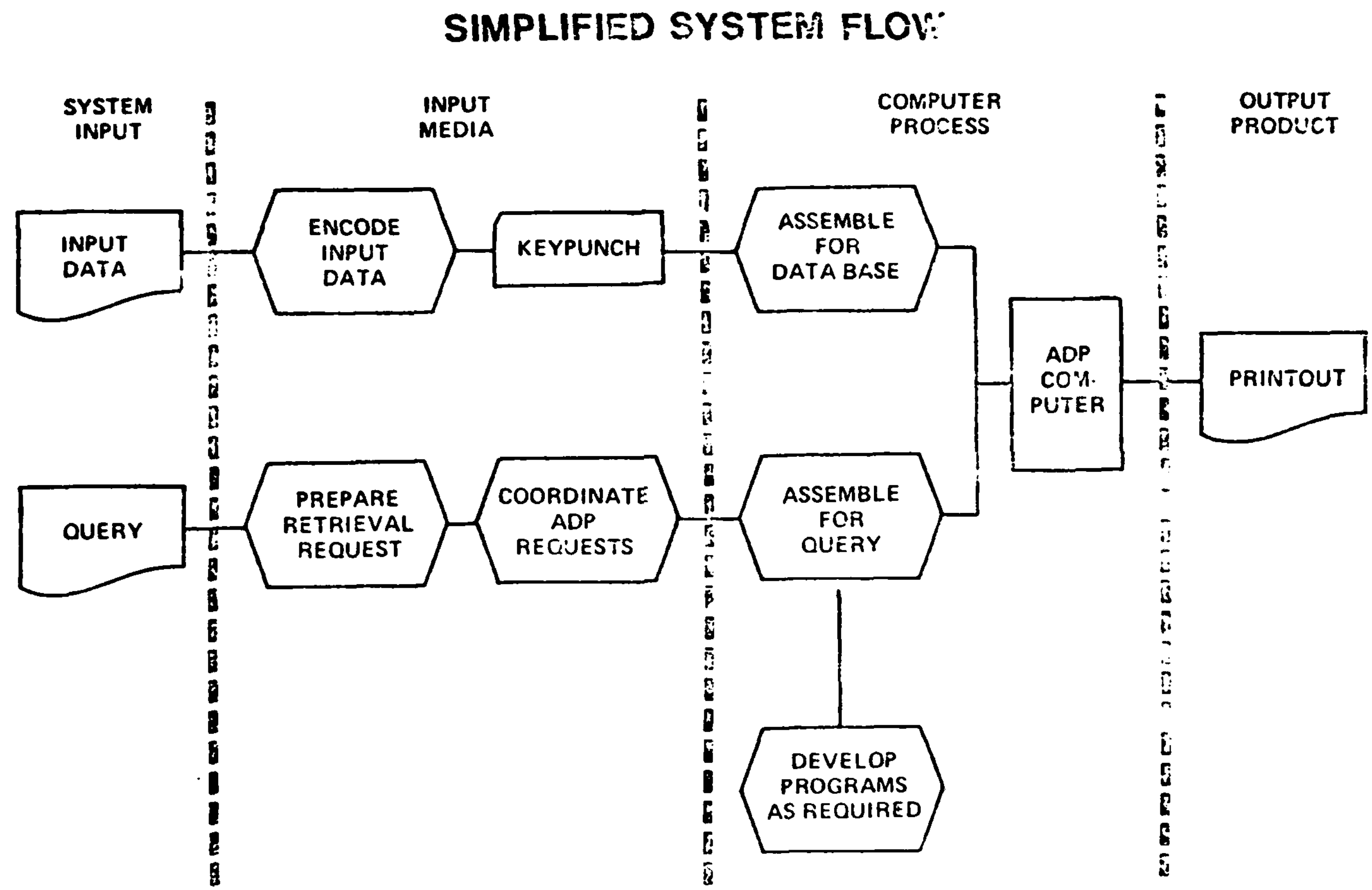
7. Permitting statistical manipulations across deficiency base to compile summary statistics on critical issues.

8. Enabling flexible access to technical data and information across past weapon system deficiencies for correlation with new deficiencies.

9. Relating system development data (program, design, mock-up decisions) to contractor demo data, NPE, BIS, OPEVAL and fleet gripes.

10. Providing research by specific technical keywords, acronyms, work unit-codes and unsatisfactory reports.

SOURCE: NAVAL AIR SYSTEMS COMMAND (AIR-531)



Source: Naval Air Systems Command, FLAGS

FIGURE 15: FLAG SYSTEM -- SIMPLIFIED PROCESS FLOW

as a guide to the retrieval criteria. The request is then processed by the NAVAIRSYSCOM computer facility. Retrieval results in a computer printout tailored to the specific requirements on the retrieval request form. Figure 16 illustrates a typical user query and output product.

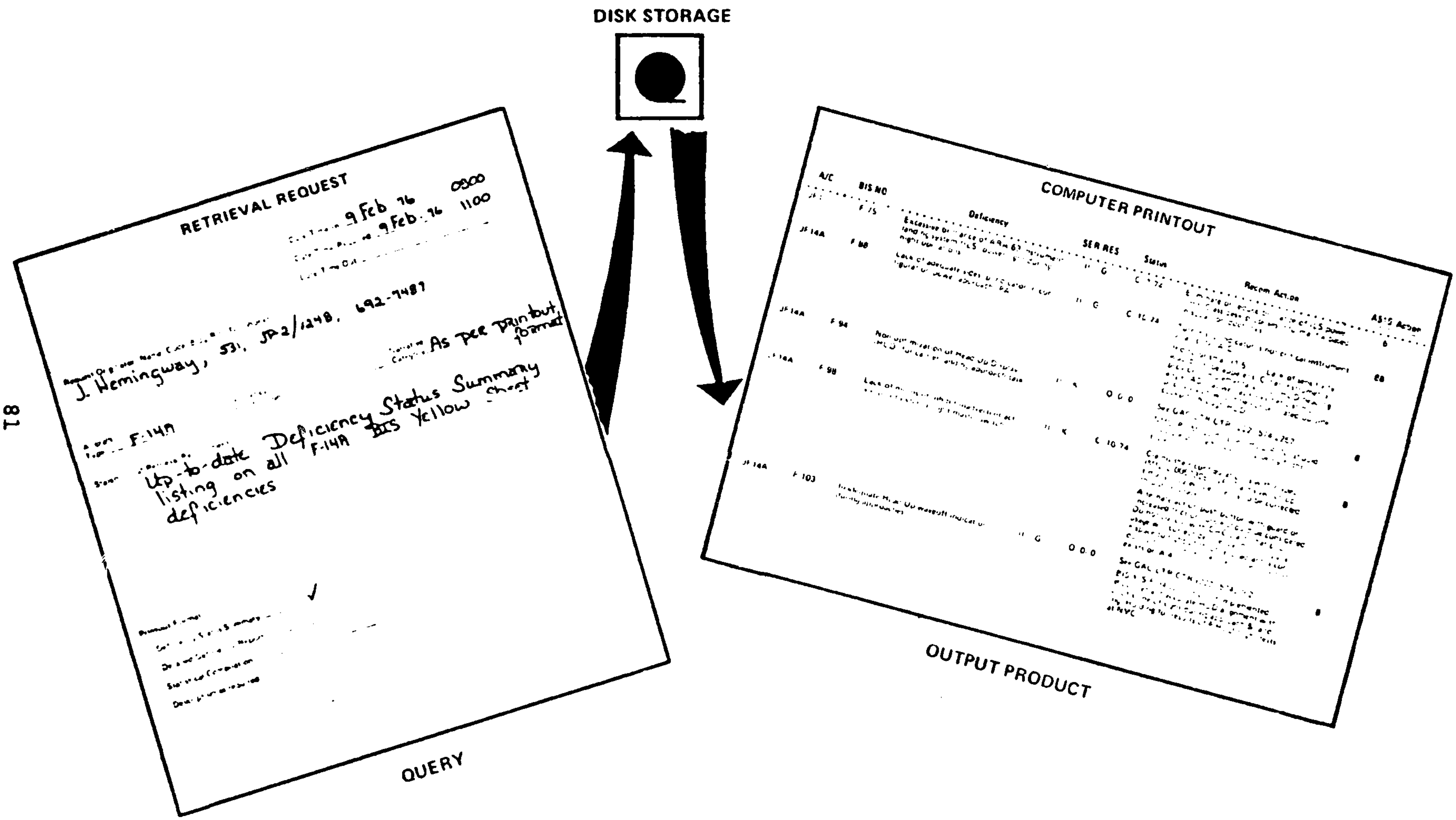
More detailed examples of retrieval requests and output products are found in Appendix E. The many advantages of FLAGS are found in Table VI.

C. GOVERNMENT-INDUSTRY DATA EXCHANGE PROGRAM

1. Background

The Government-Industry Data Exchange Program (GIDEP) chartered in 1970 became the scheme to consolidate the then existing Tri-Service Interagency Data Exchange Program (IDEP). Under this new scheme, the Chief of Naval Material was designated by the Joint Logistics Commanders to exercise over-all responsibility for GIDEP.

Essentially, GIDEP is a cooperative activity between government and industry participants seeking to conserve time, personnel and money by making maximum use of existing experience and knowledge. The program provides a means to automatically exchange a multitude of different types of technical information essential in the research, design, development, T&E, production and operational phases of the life cycle of aircraft weapon systems. [9:I-1] To accomplish this task, GIDEP is concerned with the acquisition, storage, retrieval and dissemination of technical information.



RETRIEVAL REQUIREMENT

Source: Naval Air Systems Command, FLAGS

FIGURE 16: FLAGS DATA RETRIEVAL

TABLE VI

ADVANTAGES OF SYSTEM

ADMINISTRATIVE	CORPORATE MEMORY	TECHNICAL
• FACILITATES TRACKING PROCESSING AND MANAGEMENT OF NPE/BIS YELLOW SHEETS, CORRESPONDENCE AND ACTIONS • PROVIDES RAPID RETRIEVAL OF NPE/BIS DEFICIENCY DATA IN SIMPLE FORMAT • INCLUDES ACTION DUE DATES ON SUMMARY REPORTS • PRINTS OUT SELECTIVE, DETAILED DEFICIENCY REPORTS TO FACILITATE SPECIFIC MANAGEMENT DECISIONS • PROMOTE CONSISTANCY IN RECORD KEEPING	• INDICATES "AVOID IN FUTURE DESIGN" DEFICIENCIES • ASSOCIATES T&E DEFICIENCY DATA RAPIDLY WITH MIL-SPECS/STDS FOR UPDATES AND FOLLOW-ON BUYS • IDENTIFIES COMPLEX, RECURRING DEFICIENCES FOR RESEARCH AND TECHNOLOGY ASSISTANCE • CONTRIBUTES TO R&D REQUIREMENTS DEFINITION • EXPANDS TO INCLUDE OLD OR NEW SYSTEMS AS REQUIRED	• PERMITS STATISTICAL MANIPULATIONS ACROSS DEFICIENCY DATA BASE TO COMPILE SUMMARY STATISTICS ON CRITICAL ISSUES • ENABLES FLEXIBLE ACCESS TO TECHNICAL DATA AND INFORMATION ACROSS PAST WEAPON SYSTEM DEFICIENCES FOR CORRELATION WITH NEW DEFICIENCIES • RELATES SYSTEM DEVELOPMENT DATA (PROGRAM, DESIGN, MOCK-UP DECISIONS) TO CONTRACTOR DEMO DATA, NPE, BIS, OPEVAL AND FLEET GRIPES • PROVIDES RESEARCH BY SPECIFIC TECHNICAL KEYWORDS, ACRONYMS, WORK UNIT CODES AND UNSATISFACTORY REPORTS

2. Program Objectives and Policy

Identified GIDEP objectives relevant to design are listed in Table VII.

All activities of the Naval Material Command directly engaged in the research, design, development, testing and production of mission-related Navy material are required to participate in GIDEP. Furthermore, all Navy-funded contracts for research, design, development, testing, and production of mission-related Navy material wherein the contract amount exceeds $100,000, shall require contractor participation in the program. [15:2]

3. Program Operation

GIDEP emphasis has been placed upon the rapid transmission of information to potential users, and upon having the information rapidly available upon demand. A highly simplified illustration of input and output information flow is found in Figure 17. A data retrieval system developed by GIDEP allows rapid accessibility to microfilmed information in the data bank, either through hard copy indexes or by access to the GIDEP operation center's computer data system via a remote computer terminal.

GIDEP places primary emphasis on data generated by users rather than contractors. Government specifications, contractor proprietary data and classified information are not within the scope of the current program.

TABLE VII

OBJECTIVES OF THE GOVERNMENT-INDUSTRY DATA EXCHANGE PROGRAM (GIDEP)

1. Reduce or eliminate duplicative expenditures for the testing of parts, components and materials.

2. Increase system reliability.

3. Provide advance notification of possible part, component and material failures or potential problem areas.

4. Promote standard procedures for reporting test information.

5. Facilitate communication among scientific and technical personnel working on related programs.

6. Provide a source of general parts, components and materials test data during research, development and other stages of the procurement cycle.

7. Provide failure rate and mode data to assist in design, reliability and logistics functions.

8. Provide a failure experience data bank on parts, components and materials to identify defective/suspect items, facilitate their removal from stock and preclude their reentry into new equipment designs.

9. Provide for the transfer of technology to American industry in the interest of the national economy.

SOURCE: Headquarters, NAVAL MATERIAL COMMAND (MAT-06B)

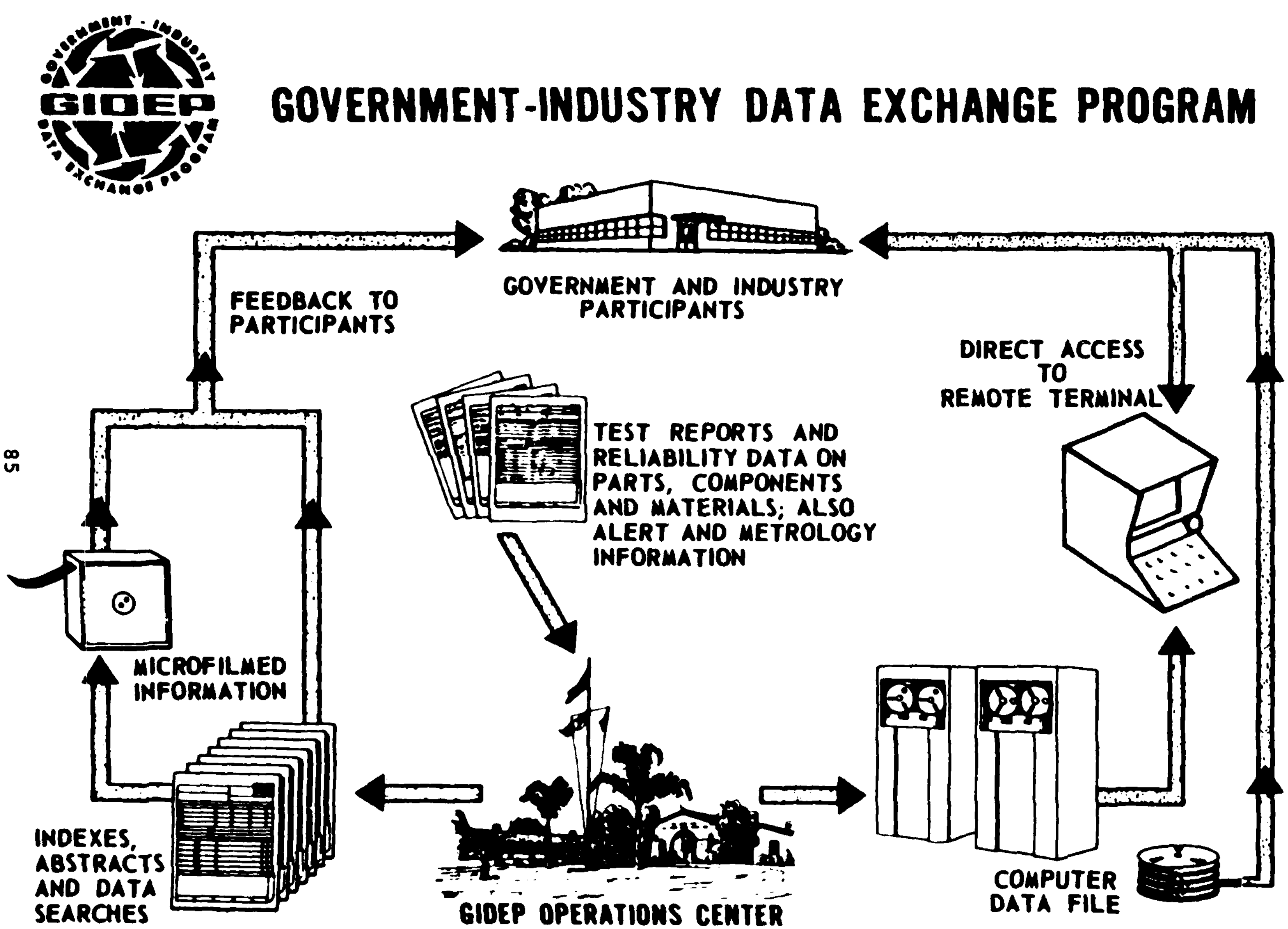


FIGURE 17: GIDEP SYSTEM INFORMATION FLOW

Code 805-Sep 77

4. Data Banks

Participants in the program are provided access to four major data banks. [9:I-5]

a. Engineering Data Bank

This bank contains engineering evaluation and qualification tests reports, nonstandard parts justification data, parts and materials specifications, manufacturing processes, failure analysis data, and other related engineering data on parts, components, materials, and processes.

b. Metrology Data Bank

This bank contains related metrology engineering data on test systems, calibration systems, and measurement technology and test equipment calibration procedures, and has been designated as a data repository for the National Bureau of Standards (NBS) metrology related data.

c. Failure Experience Data Bank

This bank contains objective failure information generated when significant problems are identified on parts, components, processses, fluids, materials, or safety and fire hazards. This data bank includes the ALERT and SAF-ALERT system and failure analysis information.

d. Reliability and Maintainability Data Bank

This bank contains failure rate/mode and replacement rate data on parts and components based on field performance information and/or reliability demonstration tests of equipment, subsystems and systems. The data bank also contains reports on theories, methods, techniques, and procedures related to reliability and maintainability practices.

5. Information Utilization

Participation in GIDEP has shown steady growth in recent years. The total number of participating government and industry activities has grown from 407 in 1974 to 554 in 1978. Documentation activity has shown a five-fold increase. Documents received (input) increased from 3,325 in 1974 to 15,257 in 1978, and documents processed increased from 3,301 in 1974 to 17,452 in 1978. [7] Design engineers, reliability and maintainability engineers, and logisticians alike, are utilizing GIDEP information to expedite and improve their decision-making process. Forms of information, groups utilizing the information and the perceived value of such information is summarized in Table VIII.

TABLE VIII

GIDEP DATA UTILIZATION

FORM OF INFORMATION	GROUPS UTILIZING	VALUE OF INFORMATION
TECHNICAL INFORMATION	• ENGINEERING–DESIGN, EVALUATION "A" PROCESS AND MATERIAL CONTROL RESEARCH AND DEVELOPMENT • LIBRARY TECHNICAL STAFF • MANUFACTURING • PROPOSAL OR CONTRACTS	• PROVIDES EXPERT BACKGROUND FOR SIMILAR PROBLEMS, AVOIDS REDUNDANT EFFORT, ASSISTS IN STATE-OF-THE ART UPDATE, AID IN TECHNOLOGY UTILIZATION, ELIMINATION OF EXCESSIVE OR COSTLY RESEARCH AND DEVELOPMENT PROGRAMS
PART EVALUATION AND TESTING	• ENGINEERING–DESIGN, EVALUATION "B" MATERIAL CONTROL, NON-STD. PART JUSTIFICATION, MAINTENANCE LIASON • PURCHASING • QUALITY ASSURANCE • RELIABILITY	• AVOIDS UTILIZATION OF MARGINAL OR POTENTIALLY BAD COMPONENTS OR PARTS, AVOIDS REDUNDANCY OF TESTING (SAVES MANPOWER, MATERIAL, TIME), ELIMINATION OF EXCESSIVE VENDOR TESTS, SHOWS AREA OF COMPONENT SPECIFICATION REQUIRING GREATEST CONTROL, SOURCE OF HISTORICAL RELIABILITY DATA ON DEVICE OPERATION, AIDS IN STANDARDIZATION OF TEST PROCEDURES, DEVELOP MORE RELIABLE PART SCREENING TECHNIQUES
PARTS JUSTIFICATION PACKAGE	• ENGINEERING–COMPONENT SPECIFICATION, PART EVALUATION, NON-STANDARD PART JUSTIFICATION, CONFIGURATION CONTROL, ENVIRONMENTAL • RELIABILITY AND QUALITY ASSURANCE	• PROVIDES PROOF OF APPROVAL OF NON-STANDARD PARTS BY GOVERNMENT, IMPROVES STANDARDS, PROVIDES OPPORTUNITY TO AVOID DUPLICATION OF EFFORT AND REDUNDANCY OF TESTING

Source: GIDEP Operations Center

TABLE VIII (Continued)

GIDEP DATA UTILIZATION

STANDARD OR PREFERRED PARTS LIST	• ENGINEERING-DESIGN, COMPONENT SPECIFICATION, CONFIGURATION CONTROL • PURCHASING	• ASSISTS IN SELECTION OF PARTS MOST UNIVERSALLY USED, ALLOWS COMPARISON OF STANDARD PART USAGE, AIDS STANDARDIZATION
CALIBRATION PROCEDURES	• METROLOGY QUALITY ASSURANCE	• ALLOWS VARIETY OF TEST SELECTION, AIDS IN DISSEMINATION OF IMPROVED TECHNIQUES FOR MORE ACCURATE CALIBRATION METHODS, AVOIDS REDUNDANCY OF PREPARING CALIBRATION PROCEDURE DOCUMENTATION, ALLOWS UTILIZATION OF EXISTING TEST EQUIPMENT
FAILURE ANALYSIS INFORMATION ALERTS	• ENGINEERING-DESIGN, COMPONENT, PART EVALUATION, CONFIGURATION, ENVIRONMENTAL, LIASON, MAINTENANCE • MANUFACTURING-PRODUCTION • PURCHASING • QUALITY ASSURANCE • RELIABILITY	• ALLOWS FAST DISSEMINATION OF POTENTIAL PART PROBLEM; AVOIDS EXTENSIVE FAILURES AND LOSS OF TIME, EQUIPMENT OR PERSONNEL; MOTIVATES EARLY RESOLUTION OF CORRECTIVE MEASURES FOR PROBLEM PARTS
SAFE-ALERTS	• ENGINEERING-SAFETY, MATERIAL CONTROL, PROCESS CONTROL • MANUFACTURING-PROCESSING	• ELIMINATION OF HAZARDOUS CONDITIONS
URGENT DATA REQUESTS	• ENGINEERING-ALL SEGMENTS • MANUFACTURING-ALL SEGMENTS • QUALITY ASSURANCE • RELIABILITY	• PROVIDES ASSISTANCE FROM EXTERNAL SOURCES FOR MAJOR PART, COMPONENT, PROCESSING, OR MATERIAL PROBLEM, ALLOWS COMMUNICATION WITH EXPERTS IN FIELD WHERE PROBLEM EXIST

Source: GIDEP Operations Center

VI. SUMMARY OF FINDINGS

Previous sections of this study have explored the various sources of operational experience information in commercial and military aircraft programs. These same sections also addressed the methods employed in the flow of such information back to the contractor and his product support and design engineering personnel. This section summarizes the more important findings made during study of the commercial and military feedback process.

A. MOTIVATION FOR FEEDBACK

The most apparent difference between commercial and military programs for operational experience feedback is economic motivation. Economic motivation provides catalytic action for commercial program but is not found as critical within military programs. To remain competitive in the commercial marketplace for additional sales of an existing aircraft model, and to achieve a favorable reputation for future sales of a new development aircraft, contractors rely heavily on "lessons learned" from operational experience. These lessons have been expressed and substantiated in terms of cost effectiveness by airlines for a long time. Military services have been fully aware of life-cycle costs only for a short time and the available data base is small by comparison with the air transport industry.

Navy Acquisition and Fleet operating practices too often preclude the contractor from adequately monitoring his deployed products. The vast majority of experience feedback to the contractor is via a feedback system external to his organization. Many specific data needs desired by the contractor are not obtainable from Navy sources. This will necessarily influence the contractor's motivation regarding feedback.

Navy and contractor information feedback systems differ in philosophy. The latter recognizes at all corporate management levels that dispatch reliability is influenced by operations and environment; that it is essential to monitor operational reliability. Consequently, contractor Technical Management Information Systems (TMIS) or operational support system data bases are drive by reliability programs. These programs in turn, drive technical advancement programs for product improvement and new design development.

The principal Navy information feedback system, its Maintenance, Material and Manpower Management System (3-M) was not conceived as a reliability monitoring system. Rather, the 3-M system was conceived as a manpower and material management system. Since 1965, the 3-M system has gradually attained a reliability orientation; however, pending a change in policy and system design, 3-M remains primarily a Maintenance, Material and Manpower Management feedback system.

Contractor TMIS and the Navy's 3-M system have evolved as mechanized systems to provide for mass-processing of

generated data into usable information. Nevertheless, both systems exhibit definite differences attributable to feedback motivation differences. Table IX summarizes the major differences.

B. ACCESS TO FEEDBACK INFORMATION

Contractor access to the numerous sources of feedback information varies widely. Access to information generated external to the contractor's organization is often difficult if not impossible. The weakest link in the external information feedback loop is in the area of qualitative design-oriented experience. The reasons appear to be a combination of two factors -- the proprietary nature and the fragmented control of such information.

1. Proprietary Information

Experience evolving from full-scale engineering development supplements experience subsequently obtained during service use by operating activities. Information and experience generated during development is of immense value to aircraft design teams in that it serves not only in making early corrections to existing system discrepancies but more importantly in providing "lessons learned" to avoid identical or similar problems from reoccurring in subsequent design efforts.

Navy acquisition policies and practices honor development experience generated in-house as proprietary information. Such information includes mock-up review chits, design review

TABLE IX

COMPARISON OF
PRINCIPAL OPERATIONAL EXPERIENCE FEEDBACK
INFORMATION SYSTEMS

Contractor (Technical Management Information Systems; TMIS)	Navy (Maintenance, Material, Manpower Management System; 3-M)
- Real time	- After the fact
- Data collected and analyzed for special purposes	- Data frequently collected and analyzed with a specific purpose in mind
- Easily changed to meet needs	- Change authorized only by higher authority
- Management respects and uses system	- Management skeptical of system
- Non-standard world-wide input data	- Standard world-wide input data
- Accurate recording reflecting management attention	- Casual recording and management attention
- Covers all maintenance	- Overhaul, major repair and major alteration maintenance excluded
- Contractor use is first level	- Contractor use is second level
- Qualitative and quantitative data	- Only quantitative data
- Remote CRT terminal capability	- Only ADP printouts
- Data limited to corporate products	- Data includes all inventory/type/model series aircraft since 1965

actions, and test and evaluation results. Development information access is limited to U.S. government agency and cognizant development contractor use only. Access or transfer of this information to other contractors within the aerospace industry is not practiced.

The industry faces a similar situation in commercial aircraft development programs. The intense competitive nature for aircraft sales to the world's airlines inhibits transfer of current and previous experience among competing contractors.

2. Fragmented Sources

Major manufacturers of transport aircraft have each developed a corporate memory regarding their previous products. Statistical (quantitative) and narrative (qualitative) information is normally contained in a technical management information system (TMIS) operated by either a commercial product support or a corporate experience retention group. Centralized information control is the key for ready access.

For Navy programs, integration efforts directed at developing a centralized data bank for Navy-wide design and operational experience have been minimal. Instead, a number of individually sponsored feedback systems serving the specific needs of the sponsor have sprouted during recent years.

A contractor must now weave his way through a multitude of fragmented Navy sources to recover development, test

and evaluation, and fleet operation experience. Recovery efforts from this extensive and fragmented data base are often time consuming and usually result in information that is difficult to correlate into terms meaningful to contractor design engineering teams.

As shown in Section V, B and C, FLAGS and GIDEP have been introduced by the Navy to provide narrative or qualitative experience information (i.e., T&E report results, design review chits, mock-up review chits, etc.). They complement the 3-M system which provides operational statistical or quantitative data from operational units as described in Section V.A.2. Basically, FLAGS and GIDEP systematize existing Navy data sources into a computerized data and information base peculiar to the needs of the two systems. Entry into these storage and feedback information systems is accomplished via specific technical keywords, acronyms, and work unit codes that are kin to the aerospace design engineering community. Entry is limited only by the degree of system software flexibility.

Each of the three feedback systems is under separate sponsorship and funding -- FLAGS with the Naval Air Systems Command, GIDEP with the Naval Material Command, and 3-M with the Chief of Naval Operations.

C. QUICKNESS OF INFORMATION FEEDBACK AND RETRIEVAL

Information on operational experience must be quickly retrievable to be of value. The air transport industry has

long recognized the importance of expediency in feedback of operational experience to the manufacturers for correction of flight equipment problems. Management emphasis on expediency is evident by world-wide real-time communication networks with field feedback sources. Operations of this type are for the most part, indirectly financed by the airline customers who find such investments highly cost-effective in reducing lost revenue caused by delayed or grounded aircraft.

Navy feedback sources are less responsive. Often, during the dynamics of full-scale engineering development, Navy T&E feedback is too late to affect the program's original design decision. Also, the receipt of Navy T&E results by the procuring activity has the effect of seeming to put NAVAIRSYSCOM personnel "on report." A defensive attitude on the part of the program manager and his technical team inevitably results. Instead of being a tool for the acquisition and fielding of the best aircraft weapons system possible, T&E feedback tends to embarrass the program management and technical team, thereby, suppressing feedback of badly needed design experience to contractor design teams.

Utilization of information on operational experience by designers during the design process on new development programs is time-critical. To be of value, designers must have the information when needed -- preferably via a remote CRT terminal and within easy reach.

FLAGS and GIDEP have the capability of improving the situation in favor of more responsive feedback and information retrieval. Both systems mechanize the data base which in today's environment has grown so that it is too extensive for unaided manual handling. Data inputs come directly from the source, thereby streamlining the existing manual process and minimizing feedback delays. Output products are available in both hard copy or through on-location CRT terminals.

D. APPLICATION OF FEEDBACK INFORMATION

In commercial aircraft programs, operational experience is greatly emphasized and a centralized feedback system has been developed. Information revealing product deficiencies is immediately applied to current programs for product improvement. Equally important, deficiencies serve as "lessons learned" for avoiding recurring or similar problems in new development programs. Experience with enhancing design features from past products is also applied to new development programs. Such features can substantially contribute to improved performance and effectiveness compared to previous products.

In Navy programs, with the exception of 3-M data, feedback is predominantly applied to solving the most visible aspects of the "now" problems associated with individual aircraft or equipment subsystems. Little incentive exists to apply this feedback information to new development programs, partly due to different priorities for Navy program managers, and partly

due to Navy acquisition policy and practices which seldom provide the necessary funding.

The Navy 3-M data bank is made available to all defense contractors. Currently, it provides only statistical (quantitative) information pertaining to aeronautical maintenance, material, and manpower on all Navy aircraft. Extensive application for 3-M is in the area of systems effectiveness. Contractors rely on 3-M data for system reliability and maintainability prediction and allocation.

FLAGS and GIDEP have both been experiencing recent growth in utilization. The founder of FLAGS, the Aircrew Systems Division (AIR-531) of the NAVAIRSYSCOM, has also been its chief user. Since its inception in the mid 1970s, FLAGS has been employed as a means for tracking air crew systems deficiencies in Naval aircraft development programs.

Recently, FLAGS has found application to the F-18 aircraft weapon system development program. In January of 1978, the NAVAIRTESTCEN highlighted the need for an automated system of tracking F-18 deficiency reports. The intent of FLAGS application in this program as discussed in Appendix F, is to derive better administrative control and management action of deficiency reports. Once again, feedback emphasis is being directed at the immediate need for improving program administrative and management functions. Little emphasis has been directed at building an experience information base for utilization by design teams in avoiding

similar or recurring problems in future Naval aircraft development programs.

As previously discussed in Section V, GIDEP utilization and fields of application have increased markedly since 1974. Breakdown of GIDEP utilization is roughly 75 percent industry and 25 percent government. Payoff for users of GIDEP is estimated at fourteen dollars recovered for every dollar spent. Despite recent growth in the number of participants and frequency of activity by both the industry and the government, the NAVAIRSYSCOM and its RDT&E field activities have taken little advantage of the services and wealth of technical experience information presently available. [8:35]

APPENDIX A

ORGANIZATIONS CONTACTED AND INTERVIEWED

Organizations contacted and interviewed during the course of this study include the following:

DEPARTMENT OF THE NAVY

Navy Maintenance Support Office

Government-Industry Data Exchange Program, Operations Center

Naval Air Rework Facility, North Island

Naval Air Systems Command

Naval Air Test Center

Naval Aviation Logistics Center

Naval Material Command

Sub-Board of Inspection and Survey, Patuxent River

AEROSPACE INDUSTRY

Air Transport Association of America

Boeing Commercial Airplane Company

General Electric Aircraft Small Engine Group

Lockheed-California Company

Piedmont Airlines

Vought Corporation

APPENDIX B

LOCKHEED – CALIFORNIA COMPANY
A Division of Lockheed Aircraft Corporation

MANAGEMENT DIRECTIVE

NUMBER: 162

FIRST ISSUED: 10- 7-76

REVISED: -

COMMERCIAL PRODUCT RELIABILITY AND MAINTAINABILITY

I. It is the policy of the Lockheed-California Company to

A. Achieve a realistically high level of dispatch reliability and utilization for its products, and to that end

1. Establish standards and specifications for reliability and maintainability commensurate with program needs and compatible with customer requirements.

2. Establish plans, programs and controls to achieve and sustain required levels of reliability and maintainability during development and production programs and during operational life.

3. Establish standards and techniques for Failure Mode and Effects Analysis (FMEA) and for Quantitative Fault Tree Analysis (QFTA) commensurate with the requirement of governmental regulatory agencies.

4. Maintain a data collection and feedback system to provide information useful in identifying and solving reliability and maintainability problems and establishing risk levels.

II. Responsibility is assigned and authority granted to

A. Commercial Product Support Branch to

1. Establish quantitative reliability and maintainability levels in proposals, contracts and specifications.

2. Establish mathematical models and techniques for computing maintenance costs, on-aircraft corrective maintenance time allocations, reliability levels, dispatch levels and probability of failure allocation.

3. Develop engineering maintainability and reliability design criteria and conduct design surveillance. Prepare maintenance engineering analyses and reliability analyses.

4. Prepare allocation of quantitative maintainability and reliability levels which are to be reflected in the program plan.

5. Establish reliability and maintainability test requirements for components and sytems as necessary to perform Quantitative Fault Tree Analyses, Failure Mode and Effects Analyses, Maintenance downtime assessment, and to establish Trouble Shooting Procedures.

II. A. 6. Evaluate progress of operational programs and report to management concerning achievement of maintainability levels, reliability levels, and probability of failure allocations.

7. Establish requirements for piece-part screening and burn-in/run-in in specifications and proposals. Monitor these parameters in operational programs as necessary to achieve the required reliability levels, dispatch levels and probability of failure allocations.

8. Provide technical direction over the execution of initial measurement programs and participate in all commercial reliability and maintainability measurement programs.

9. Identify and analyze problem areas affecting achievement of maintainability and reliability goals and work with cognizant organizations to establish corrective action.

10. In coordination with other branches, negotiate and maintain liaison with:

   a. LCC customers regarding achievement of reliability and maintainability goals.

   b. LCC suppliers regarding achievement of reliability and maintainability requirements, and compliance with their R&M program plans.

   c. Regulatory agencies regarding maintenance program development and revisions, equipment reliability performance, and achievement of probability-of-failure levels.

11. Prepare maintenance and facilities planning documents conforming to maintainability plans and requirements. Coordinate with Engineering in the resolution of any problems arising from engineering plans and requirements.

12. Collect and provide data from field operations and field flight test programs to establish equipment reliability level.

13. Establish product reliability and maintainability data needs for inclusion in the integrated failure-data collection and feedback systems. Participate in the development of data collection program plans and in the application of automatic data processing techniques.

14. Provide the Engineering Branch with M&R assistance in the design of each Calac commercial product so that it incorporates requirements for maintainability, reliability and supportability consistent with those for performance, initial and operational cost, producibility, and weight and stress.

II. A. 15. Perform Calac coordinating efforts for participation in industry and government activities affecting maintainability and reliability techniques. Maintain liaison with Lockheed companies, as appropriate, to insure timely interchange of maintainability, reliability and risk measurement and prediction techniques.

B. Engineering Branch to

1. Design each Calac product so that requirements for maintainability, reliability, and supportability are given consideration equal to those for performance, initial and operational cost, producibility, and weight and stress.

2. Assure that all data and information on reliability and maintainability problems which become evident during development test programs are made available to cognizant design, reliability and maintainability personnel.

C. Quality Assurance Branch to

1. Participate with the Commercial Product Support Branch in establishing programs and controls to verify conformance of products and components to reliability and maintainability requirements.

2. Establish and maintain an in-plant data center and acquire in-plant production failure data sufficient to support reliability and maintainability activities.

3. Maintain liaison with suppliers in coordination with Materiel and Commercial Product Support.

4. Coordinate with responsible Branches in the identification of design problems and in the analysis of failure.

5. Participate with the responsible Branch in the conduct of reliability and maintainability measurement programs for in-plant activities.

D. Materiel Branch to

1. Negotiate supplier guarantees for reliability and maintainability on selected items as required to satisfy overall system requirements.

2. Participate with Quality Assurance and Commercial Product Support in the negotiation for correction of quality and/or design deficiencies necessary to achieve required reliability and maintainability levels.

II. E. Administrative & Computer Services Branch to

1. Develop, at request of using Branches, automatic data processing programs to support the reliability and maintainability data collection and feedback system.

2. Provide automatic data processing reports to affected organizations according to programmed requirements.

F. Commercial Program Planning to

1. Issue program letters when required to coordinate interbranch activities associated with reliability and maintainability plans.

Establish and monitor schedules.

G. All affected organizations to

1. Participate in the collection and evaluation of reliability and maintainability data when requested to do so by the cognizant branches.

Explanatory Remarks

1. Management Directive 40 establishes the Calac policy to ensure that Calac products meet all requisite standards of quality.

2. Management Directive 85 establishes the Calac policy to provide support equipment and related data required for the efficient operation and maintenance of each Calac product.

3. Management Directive 143 establishes the Calac policy to provide service support required for the proper operation, maintenance, and best use of each Calac product.

4. The term "Reliability" includes the establishment and measurement of the product risk level, failure mode and effects analysis, and quantitative fault tree analysis.

5. "Risk" is defined as the quantitative probability of a flight critical failure mode occurring within a specific interval.

D O Wood

D. O. Wood
President
Lockheed-California Company

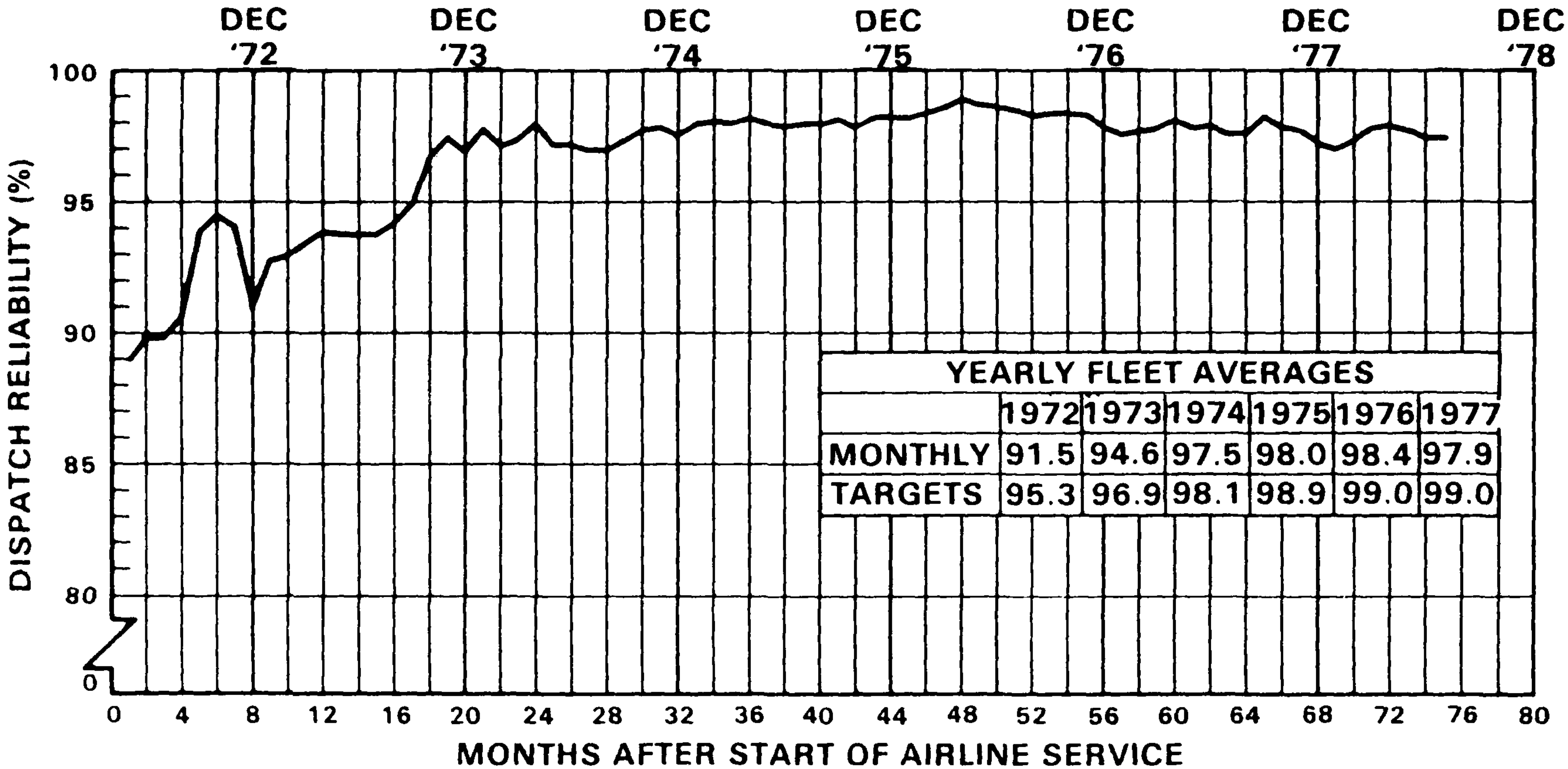
APPENDIX C

SAMPLES OF OUTPUT REPORTS FROM LOCKHEED'S OPERATIONAL SUPPORT DATA SYSTEM

The following reports are a sampling of the type and variety of reports periodically processed by the L-1011 TriStar OSDS program. These standard output, yet specific reports, are considered pertinent to the area of previous design experience feedback.

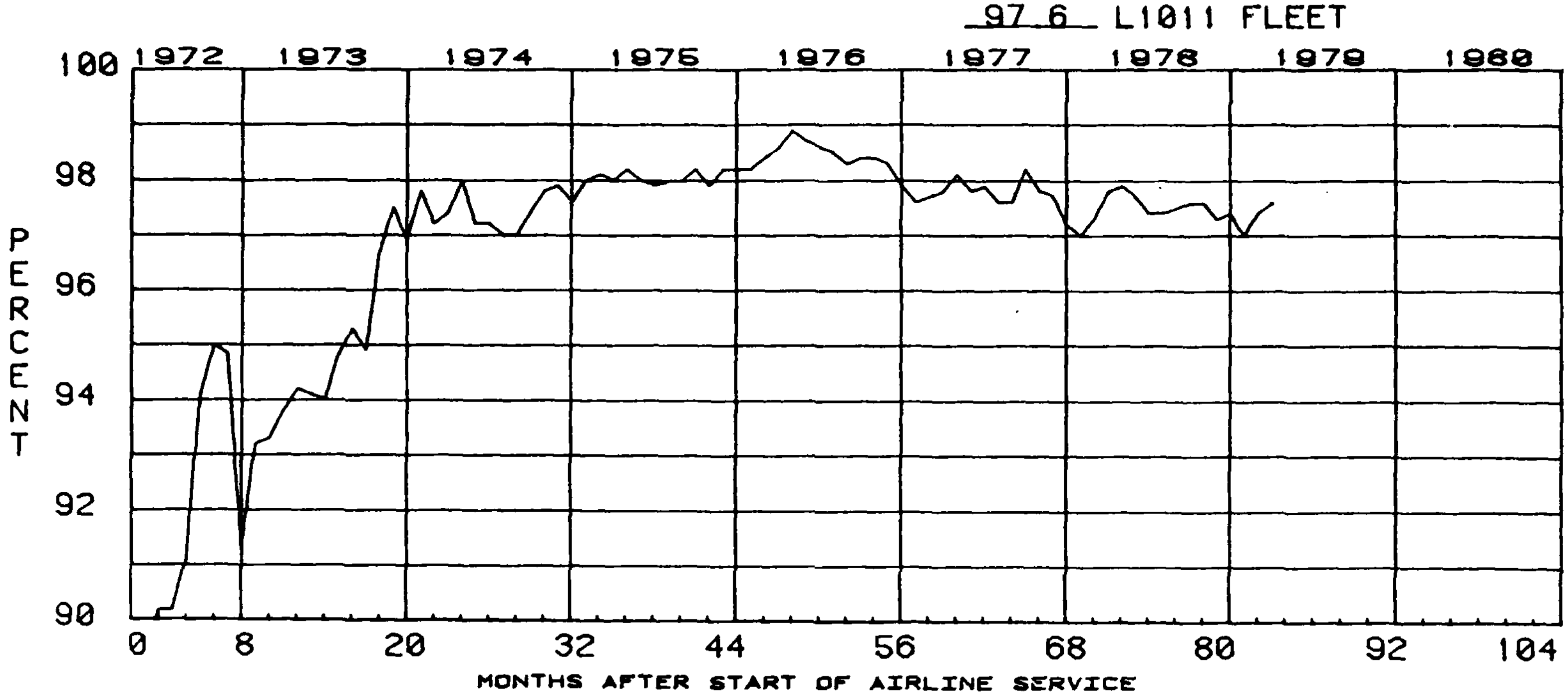
SOURCE: Lockheed-California Company

DISPATCH RELIABILITY-FLEET



TriStar L1011 MECHANICAL DISPATCH RELIABILITY

0103000
4-20-79



BASIC CAUSES:	J	F	M	A	M	J	J	A	S	O	N	D
	1979											
ATA 71-79 PROPULSION GROUP	148	122	125									
ATA 32 LANDING GEAR	54	39	54									
ATA 27 FLIGHT CONTROL	62	45	37									
ATA 52 DOORS	46	37	37									
ATA 24 ELECTRICAL POWER	21	22	41									
OTHER AIRCRAFT SYSTEMS	213	151	150									
TOTALS:	544	416	444									

SY0319

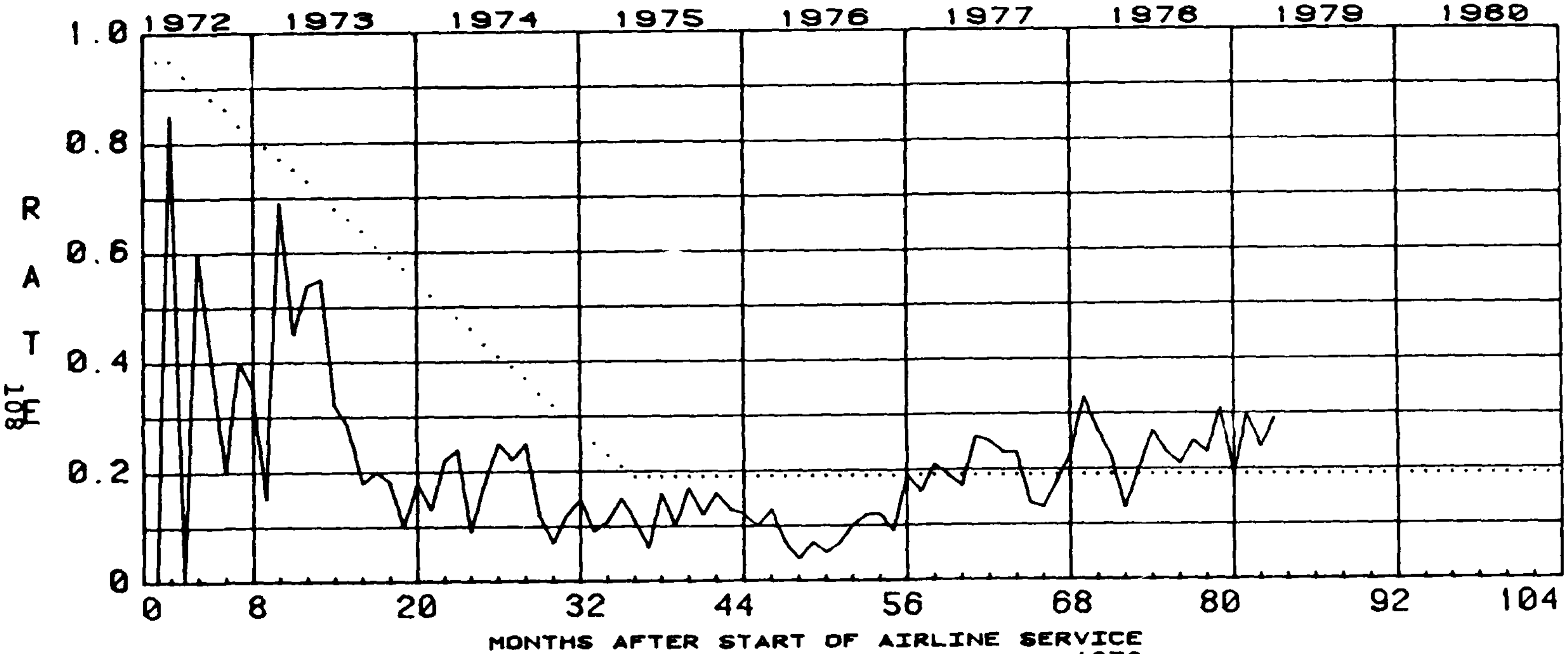
4-24-79

TriStar L-1011

ATA 32 LANDING GEAR

MECHANICAL DISPATCH RELIABILITY PER 100 DEPARTURES

0.19 TARGET   0.29 FLEET



BASIC CAUSES:	1979 J	F	M	A	M	J	J	A	S	O	N	D
ATA 3210 MAIN LANDING GEAR & DOORS	8	9	6									
ATA 3220 NOSE LANDING GEAR & DOORS	5	1	6									
ATA 3230 EXTENSION & RETRACTION	5	10	4									
ATA 3240 WHEELS/TIRES AND BRAKES	32	18	34									
ATA 3250 STEERING	1	1	2									
ATA 3260 POSITION & WARNING	3	0	2									
ATA 3270 SUPPLEMENTAL GEAR	0	0	0									
TOTALS:	54	39	54									

ATA 32 LANDING GEAR

During the past quarter, one hundred forty-seven revenue departures were delayed by problems in the landing gear system. The delay rate was 0.28 per 100 revenue departures.

The landing gear system problems causing the delays are tabulated as follows:

- Tire problems – 50 delays
- Landing gear struts – 23 delays
- Brake system problems – 19 delays
- Anti skid system – 11 delays
- Position and warning system – 5 delays
- Landing gear selector valve – 5 delays
- Retract actuator – 4 delays
- Parking brake system – 3 delays
- Landing gear phase control valve – 2 delays
- Miscellaneous landing gear system problems – 25 delays

ACTION

- MAIN LANDING GEAR ACTUATION (MLG)
  - S/B 32-081 and 32-086, *providing the cable rerouting and* stronger spring respectively for the MLG Phase Control Valve have been released and kits have been shipped to the airlines that have submitted purchase orders.
  - S/B 32-091 provides for the modification/replacement of the MLG Phase Control Valve. Production effectivity is S/N 1110 – and up. Kits were supplied to all airlines.
- NOSE WHEEL STEERING DISCONNECT ACTUATOR
  - The present program for resolving the steering disconnect problems has been revised. A new two phase program has been initiated as follows:

    Phase I EJN 3H1028 "Avionics Rudder Pedal Steering Disconnect Actuator" – Replace the present MCD Actuator with the Avionics Actuator, change interfacing bearing and add access cutouts to floor structure. This change will be programmed into ship 1157 for new production.

    A no parts Service Bulletin 32-137 was issued 7-20-78 *to authorize installation* of this actuator, with the interfacing changes, should the customer elect to implement this change on earlier aircraft.

    Phase II SB32-138 Nose Gear Steering Disconnect Actuator System Modification was released February 1, 1979.

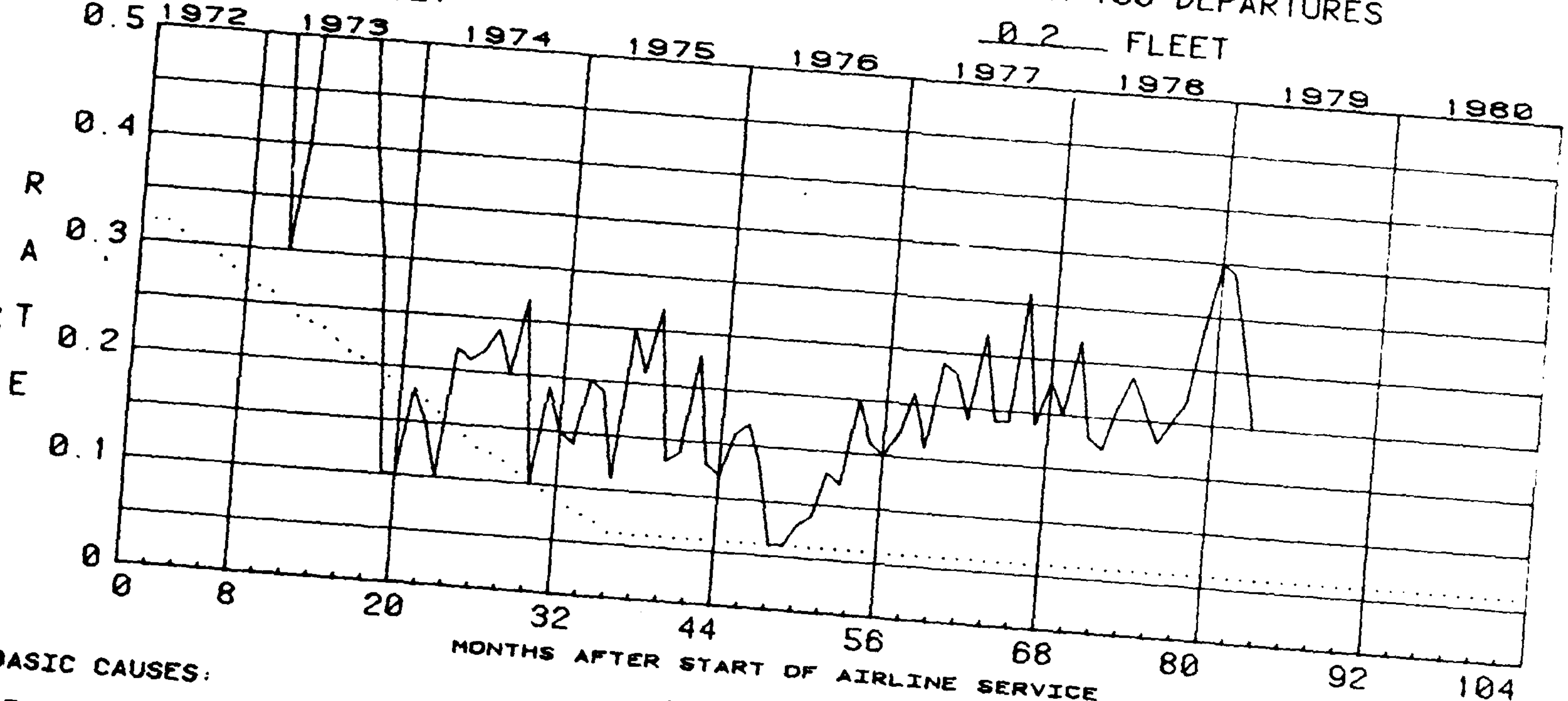
*S/B 32-138 will be issued ECD week of 1-29-79 to authorize the Phase II system.

ATA 27 FLIGHT CONTROLS

MECHANICAL DISPATCH RELIABILITY PER 100 DEPARTURES

SY03008

4-24-79



BASIC CAUSES:	J	F	M	A	M	J	J	A	S	O	N	D
1979												
ATA 2710 AILERON & TRIM	8	2	3									
ATA 2720 RUDDER & TRIM	6	6	5									
ATA 2750 FLAPS	20	13	10									
ATA 2760 SPOILER & DRAG SYS	12	10	8									
ATA 2780 LIFT AUGMENTATION	11	10	8									
OTHER ATA SUB CHAPTERS	5	3	3									
TOTALS:	62	44	37									

ATA 27 FLIGHT CONTROLS

HIGHLIGHTS

During the past quarter, one hundred forty-three revenue departures were delayed by flight control system problems. The delay rate was 0.27 per 100 revenue departures.

The flight control system problems causing the delays are tabulated as follows:

- Aileron wheel control – 3 delays
- Aileron actuator – 3 delays
- Aileron system – 7 delays
- Elevator and trim – 4 delays
- Rudder hydraulic limiter – 8 delays
- Rudder hydraulic limiter pressure switch – 2 delays
- Miscellaneous rudder hydraulic limiter – 7 delays
- Stablizer system problems – 7 delays
- Flap load relieving system computer – 5 delays
- LRS actuator – 2 delays
- Flap asymmetry comparator – 7 delays
- Flap power drive unit – 5 delays
- Flap position indications – 3 delays
- Flap asymmetry brake – 3 delays
- Miscellaneous flap system problems – 18 delays
- Spoiler servo shut-off valve – 3 delays
- Spoiler servo control assembly – 5 delays
- Spoiler Electric-Actuator – 9 delays
- Miscellaneous spoiler system problems – 13 delays
- Slat power drive unit – 6 delays
- Slat asymmetry comparator – 7 delays
- Slat position indications – 2 delays
- Miscellaneous slat system problems – 14 delays

ACTION

- FLAP/SLAT SYSTEM
  - The –115 vented asymmetry compartor is available. Supplier's Service Bulletin Number 472085-111-27-2.
  - S/B 27-141 'A' brake drain mod
  - S/B 27-144 fills rotary trnasducer with oil
  - Rear mount CW S/B 179602-27-1/-2
  - Rear mount inspection S/B in work
  - Rear mount removal and installation newsletter 27-51-34
  - Revised 90^{o} angle gearbox CW S/B 179618-27-01
  - New rudder fuse ground test. MM 29-11-74 Feb 15/78
  - Slat PDU investigation by Sundstrand to provide control valve fix. *Supplier is submitting S/B.*
  - LRS actuator – LSI S/B 21191-27-01 replaces potentiometer
  - LRS computer – S/B 093-27-084 inhibits LRS latching on ground and delays airborne latching unless fault remains 10 seconds.
- FLIGHT CONTROL PRESSURE SWITCHES
  - Lockheed has initiated a program to investigate the reported problems with various pressure switches used throughout the flight control systems.
- SPOILER ACTUATORS
  - Lucas Aerospace S/B 4082-27-8 and 4082-27-9 – improve environmental protection, thermal protection and install ceramic type capacitor.

COMPONENT RELIABILITY IMPROVEMENT PROGRAM

L-1011 TriStar

ATA NO. 255207 FIXED DRIVE ASSY

	MTUR	MTBF	RATIO
CURRENT RELIABILITY	3855	3887	1.01:1

SERVICE PROBLEMS/REPAIR ACTIONS

ITEM DESCRIPTION	% OF TOTAL	CORRECTIVE ACTION
ROLLER P/N 717-2509	65%	
ARM - OUTBD LEVER P/N 717-2050	8%	SB25-168
SCREW - MS16998-48	5%	
SPRING - RUBBER P/N 717-2141	5%	
CUP - SPRING RETAINER P/N 717-2086	4%	
BASE PLATE P/N 717-2080	4%	
BOLT P/N AN4C77A	2%	
BEARING SUPPORT HOUSING P/N 717-2089 SHIM P/N 717-2816 RING - RETAINING P/N MS16227-4075 KEY - P/N MS35756-33 PLANET CAGE ASSY P/N 717-2590 RETAINING RING (V89462) P/N 5100-46 SHAFT - MAIN ROLLER P/N 717-2091	ALL 7% RANDOM FAILURES	
	100%	

SEE ENGINEERING COMMENTS

25-52-07 — DRIVE ASSY, FIXED AND 25-52-14 — ACTUATOR, RETRACT

BOTH UNITS ARE EXPERIENCING LOW ROLLER LIFE AS WELL AS ROLLER BUSHING WEAR. AIRLINE IS PRESENTLY RETREADING THE ROLLERS WITH GOOD SUCCESS. LOCKHEED SUPPORT CENTER RECENTLY CONDUCTED A SURVEY ON BOTH UNITS; HOWEVER, AS OF THIS TIME WE HAVE NOT SEEN THE RESULTS OF THIS SURVEY.

L-1011 TriStar

COMPONENT RELIABILITY IMPROVEMENT PROGRAM

ATA NO.	NOMENCLATURE: FIXED DRIVE ASSY	VENDOR: WESTERN GEAR
25-52-07	LAC P/N 672587-107	717-2000-3

CORRECTIVE ACTION:

1. SB25-168 SIMPLIFIES FIXED DRIVE SYSTEM BY ELIMINATING SOLENOID BRAKES, MANUAL RELEASE SYSTEM, EMI FILTERS, AND RECTIFIERS FROM C-1 AND C-2 CARGO COMPARTMENTS. MODIFIED SYSTEM ALLOWS DRIVE ROLLERS TO FREE-WHEEL WHEN DRIVE MOTOR IS DE-ENERGIZED. EFFECTIVITY: SB25-168 1001 TO 1082, PROD 1083 AND UP.

2. DRIVE ROLLERS ARE RETREADABLE BY AIRLINE OPERATOR OR SUPPLIER (WESTERN GEAR). THE 2.40" DIA IS MAX FOR POLYURETHANE ROLLER UNLESS A COMPLETE REDESIGN OF THE FIX-DRIVE ASSY AND CARGO FLOOR IS STARTED.

3. LOCKHEED SUPPORT CENTER IS LOOKING AT THE PERFORMANCE COMPARISON OF THE SELF-LIFTING VERSUS FIXED DRIVE. THE -500 SERIES USES ALL SELF-LIFTING TYPE.

APPENDIX D

AVIATION RECURRING AND ON DEMAND INFORMATION REPORTS PRODUCED BY NAMSO

Aviation Information Reports produced by the Navy Maintenance Support Office and available to both Department of Defense activities and Defense contractors are listed on the following pages of this appendix.

SOURCE: Navy Maintenance Support Office Instruction, NAMSOINST 4790.1, Dated 1 December 1978

PART II - 3-M AVIATION INFORMATION REPORTS LISTED IN REPORT NUMBER SEQUENCE

H = Hardcopy m = microfilm f = microfiche

NUMBER	FREQUENCY	FORMAT	TITLE
NAMSO 4790.A2065-01	Annual *	Hf	Organizational Code Master Listing
NAMSO 4790.A2092-01	Monthly	Hmf	Aviation Readiness Utilization Summary
NAMSO 4790.A2092-02	Monthly	Hmf	Aviation Readiness Utilization Untimely/Discrepancy Data List (By Aircraft)
NAMSO 4790.A2092-03	Monthly	Hmf	Aviation Readiness Utilization Untimely/Discrepancy Data List (By Data Processing Activity)
NAMSO 4790.A2092-04	Monthly	H	Aviation Untimely/Discrepancy Summary
NAMSO 4790.A2096-02	Monthly	H	Aviation AIMD Item Processed Summary
NAMSO 4790.A2096-03	Monthly	H	Aviation AIMD Repair/Support Action Summary
NAMSO 4790.A2097-01	On-Demand	H	Type Equipment History Inquiry
NAMSO 4790.A2107-01	Monthly	Hmf	Fleet Failure Summary by Type Equipment and Work Unit Code
NAMSO 4790.A2107-04	Monthly	H	Flight Hours Per Failures for Aircraft Electric Power and Engine Starting Items
NAMSO 4790.A2142-01	Quarterly	Hmf	Fleet Weapon System Reliability and Maintainability Statistical Summary
NAMSO 4790.A2142-02	Quarterly	Hmf	Work Unit Code System Reliability and Maintainability Summary
NAMSO 4790.A2142-03	Quarterly	Hmf	Reliability and Maintainability Summary for Selected Work Unit Codes
NAMSO 4790.A2142-04	Quarterly	Hmf	Reliability and Maintainability Trend Analysis Summary
NAMSO 4790.A2151-01	On-Demand	H	Repair Cycle Data Report (MDR-10)
NAMSO 4790.A2152-01	Monthly	H	Data Processing Activity Analysis
NAMSO 4790.A2152-02	Quarterly	H	Aviation Data Receipts Monitoring Digest
NAMSO 4790.A2162-01	On-Demand	H	Special Flight Summary Report (76 transactions)
NAMSO 4790.A2162-02	On-Demand	H	Special Flight Summary Report (71, 76 and 79 transactions)
NAMSO 4790.A2166-01	On-Demand	H	Individual Aircraft History Summary

NUMBER	FREQUENCY	FORMAT	TITLE
NAMSO 4790.A2210-01	Annual *	Hf	Aviation Type Equipment Code List
NAMSO 4790.A2212 (Series)	Monthly	H	Error Statistics and Trend Analysis Report 4790.A2212-01 - Organization 4790.A2212-02 - Air Group 4790.A2212-03 - Type Commander 4790.A2212-04 - Functional Commander
NAMSO 4790.A2241-01	Monthly	Hmf	Aviation Readiness Utilization Summary (Special)
NAMSO 4790.A2242-01	Monthly	Hmf	Aviation Corrosion Control/Treatment Report
NAMSO 4790.A2243-01	Monthly	Hmf	GSE Readiness Utilization Summary
NAMSO 4790.A2245-01	Quarterly	Hmf	Component Repair Report
NAMSO 4790.A2245-03	Quarterly	Hmf	Consolidated Reparable Item Data Summary
NAMSO 4790.A2257-01	On-Demand	H	3-M Aviation MDCS Validation Specifications
NAMSO 4790.A2281-01	On-Demand	H	Special Material Report
NAMSO 4790.A2298-01	On-Demand	H	Reliability and Maintainability Summary for Selected Equipments
NAMSO 4790.A2303-01	Semi-Annual	Hmf	Reparable Component Installation and Removal Report
NAMSO 4790.A2371-01	On-Demand	H	Special Maintenance Data Report
NAMSO 4790.A2371-02	On-Demand	H	Special Maintenance Data Report (Summarized)
NAMSO 4790.A2372-01	On-Demand	H	Failed Parts Report (MDR-9)
NAMSO 4790.A2391-01	Quarterly	H	Aircraft Maintenance Cost Report
NAMSO 4790.A2426-01	Quarterly	Hmf	AIMD Reparable Component Action Summary
NAMSO 4790.A2453-01	Quarterly	H	Engine Removal/Foreign Object Damage Report
NAMSO 4790.A2525-01	Quarterly	H	Aviation Activity Reporting Analysis Summary (AREAS)
NAMSO 4790.A2551-01	On-Demand	H	No Defect Item Analysis Summary
NAMSO 4790.A2707 (Series)	Quarterly	Hmf	Part Number/National Stock Number/Work Unit Code Cross Reference Data 4790.A2707-01 - Part Number to Work Unit Code 4790.A2707-02 - NSN to Part Number 4790.A2707-04 - Aircraft/WUC to Part Number

NUMBER	FREQUENCY	FORMAT	TITLE
NAMSO 4790.A2936 (Series)	Monthly	Hmf	Aircraft Information Digest (AID)
			4790.A2936-01 - Navy-wide
			4790.A2936-02 - Sixth Fleet
			4790.A2936-03 - Seventh Fleet
NAMSO 4790.A2958 (Series)			Readiness Utilization Summary History
	Quarterly	mf	4790.A2958-01 - Navy-wide Scrubbed Data
	Quarterly	mf	4790.A2958-02 - Navy-wide Unscrubbed Data
	Monthly	Hmf	4790.A2958-03 - Sixth Fleet Unscrubbed Data
	Monthly	Hmf	4790.A2958-04 - Seventh Fleet Unscrubbed Data
NAMSO 4790.A2961-01	On-Demand	H	AIMD Repair History Summary
NAMSO 4790.A3063-01	Quarterly	H	Engine Maintenance Evaluation Report
NAMSO 4790.A3179-01	Quarterly	Hmf	Aircraft Component Effectiveness Report (ACE)
NAMSO 4790.A3179-03	Quarterly	H	Component Application and Performance Summary
NAMSO 4790.A3245-01	Monthly	H	Selected Component Analysis Report
NAMSO 4790.A3364-01	Monthly	Hmf	Aircraft Degradation Ranking Summary
NAMSO 4790.A3364-03	Monthly	Hf	Common Avionics Degradation Ranking Summary
NAMSO 4790.A3364-04	Monthly	Hf	Common Engine Degradation Ranking Summary
NAMSO 4790.A3448-01	Quarterly	Hmf	AIMD Production and Capability Summary
NAMSO 4790.A3458-01	Monthly	Hmf	Aircraft Operational Status Report
NAMSO 4790.A3699-01	Monthly	Hmf	GSE Information Digest (TEC Sequence)
NAMSO 4790.A3706-01	Monthly	H	Operations Per Failure for Aircraft Electric Power and Engine Starting Items
NAMSO 4790.A3758-01	Monthly	H	USMC Command Statistics
NAMSO 4790.A3759-01	Monthly	Hf	NOR/RMC/Maintenance Analysis Report
NAMSO 4790.A3759-02	Monthly	Hf	High NOR/RMC Summary Analysis Report
NAMSO 4790.A3855-01	Monthly	Hmf	3-M Aviation Cannabilization Analysis Summary

* Cumulative quarterly supplements

APPENDIX E

SAMPLES OF FEEDBACK LOOP ACTION GENERATION SYSTEM (FLAGS) RETRIEVAL REQUESTS AND OUTPUT PRODUCTS

The following three examples, consisting of retrieval request followed by output product, exhibit the inherent flexibility of FLAGS to analyze, correlate and retrieve information of different types and format.

Example 1 - Deficiency Status Summary (p.119-120)

Example 2 - BIS Y/S Deficiency Identification (p.121-122)

Example 3 - Detailed Deficiency Report (p. 123-124)

SOURCE: Naval Air Systems Command

Date/Time In: 9 Feb. 76 0800

Date/Time Required: 9 Feb. 76 1100

Date/Time Out: ______

Request Originator (Name, Code, Bldg/Rm, Telephone):

J. Hemingway, 531, JP-2/1248, 692-7487

Aircraft Type: F-14A   Deficiency Identification ______   Narrative Category: As per printout format

Statement of Retrieval Requirement:

Up-to-date Deficiency Status Summary listing on all F-14A BIS Yellow Sheet deficiencies.

Printout Format:

- Deficiency Status Summary: ✓
- Detailed Deficiency Report: ______
- Statistical Compilation: ______
- Description as required:

RETRIEVAL REQUEST (EXAMPLE #1)

A/C	BIS NO.	Deficiency	SER	RES	Status	Recom/Action	A5?? Action
JF14A	F 75	Excessive brilliance of ARA-63 instrument landing system (ILS) power light during night operations.	II	G	C 7/74	Eliminate or reduce brilliance of ILS power light. Class desk proposes informal fix based in squadron doctrines.	6
JF14A	F 88	Lack of adequate sideslip indicator in configuration power approach (PA).	II	G	C 10/74	Turn + slip indicator is not critical instrument as an older A/C. Indicator small (1.5 in.). Lack of sensitivity would not be apparent. Other instruments provide complimentary info (HUD heading angle, ADI) as well as kinesthetic stimuli, pilot's vision would be concentrated outside cockpit, through HUD	88
JF14A	F 94	Non-optimization of Head Up Display (HUD) for carrier landing approach task.	II	K	O 0/-0	See GAC LTR CTR (222)/574-2262. NMC, Pt Mugu dropped HUD 4 IN should alleviate problem - currently being flight tested	8
JF14A	F 98	Lack of means of inhibit inadvertent activation of external light master switch	II	K	C 10/74	Claims their configuration is within spec (MIL-L-006730B) WF. Claims switch optimally located, deficiency to be corrected thru pilot usage. Alternate action push button with guard or increased friction toggle should be considered Do not concur with GAC claim that pilot usage will correct deficiency. Control panel + space to right of throttle quadrant is conducive to inadvertent actuation. Problem still exists on A-4.	8
JF14A	F 103	Inadequate Head-Up waveoff indication during approaches.	II	G	O 0/-0	See GAC LTR CTR (222)/5742262. BIS Y/S F-94 correction, if implemented, should effect accurate HUD alignment with pilot's line of sight during approach & landing. Holding for results of P HUD flight tests at NMC.	6

DEFICIENCY STATUS SUMMARY (EXAMPLE = 1)

Date/Time In: 5 Feb. 76   0830

Date/Time Required: 6 Feb. 76 1000

Date/Time Out: ______

Request Originator (Name, Code, Bldg/Rm, Telephone):

J. Hemingway, 531, JP-2/1248, 692-7487

Aircraft Type: F-14A   Deficiency Identification ______   Narrative Category: as per printout format

Statement of Retrieval Requirement:

Listing of all F14A yellow sheet with assigned keywords:

Flight maneuvers, carrier landings   79C

Printout Format:

Deficiency Status Summary: ✓

Detailed Deficiency Report: ______

Statistical Compilation: ______

Description as required:

RETRIEVAL REQUEST (EXAMPLE - 2)

A/C	BIS NO.	Deficiency	SER	RES	Status	Recom/Action	A510 Action
JF14A		Keywords: flight maneuvers, carrier landings					
JF14A	F 88	Lack of adequate sideslip indicator in configuration power approach (PA).	II	G	C 10/74	Turn + slip indicator is not critical instrument as on older A/C. Indicator small (1.5 in.). Lack of sensitivity would not be apperent. Other instruments provide complementary info (HUD heading angle, ADI) as well as kinesthetic stimuli. Pilot's vision would be concentrated outside cockpit, through HUD	8B
JF14A	F 94	Non-optimization of Head Up Display (HUD) for carrier landing approach task	II	K	O 0/-0	See GAC LTR CTR (222)/574-2262. NMC, Pt. Mugu dropped HUD 4 IN should alleviate problem - currently being flight tested	8

BIS Y/S DEFICIENCY IDENTIFICATION (EXAMPLE #2)

Date/Time In: 5 Feb 76 0900

Date/Time Required: 6 Feb 76 1430

Date/Time Out: ______________

Request Originator (Name, Code, Bldg/Rm, Telephone):
J. Hemingway, 531, JP-2/1218, 692-7487

Aircraft Type: F-14A

Deficiency Identification: C382

Narrative Category: 111

Statement of Retrieval Requirement: Narrative printout of all available information on 815 Yellow Sheet (i.e. "Lack of means to inhibit inadvertent activation of external light master switch")

Printout Format:

Deficiency Status Summary: ______________

Detailed Deficiency Report: ✓

Statistical Compilation: ______________

Description as required:

RETRIEVAL REQUEST (EXAMPLE #3)

YS JF14A F 98

STATUS: C 10/74 SERIOUSNESS: II RESPONSIBILITY: K

1 **TITLE**
– Lack of means of inhibit inadvertent activation of external light master switch.

2 **DISCREPANCY SUMMARY**
– Location of external lights master switch makes it vulnerable to pilot hand, arm, or wrist movements during flap configuration changes, when pilot must reach around throttle to grasp flap handle. Night operations. Approach Power Compensator Switch (APCS). Air Inlet Control System Switch (AICS).

3 **BACKGROUND INFO**
– Inadvertent actuation of external lights master switch is no problem peculiar to F-14A only. A-4M went thru throttle handle redesign. S-3A attempted to use half-moon guard, but was removed.

4 **NATC/NMC RECOM.**
– Contractor investigate + take corrective action.

5 **CONTRACTOR STATEMENT**
– Claims their configuration is within spec (MIL-L-006730B) WF. Claims switch optimally located, deficiency to be corrected thru pilot usage.

6 **AIR-5313 RECOM.**
– Alternate action push button with guard or increased friction toggle should be considered. Do not concur with GAC claim that pilot usage will correct deficiency. Control panel and space to right of throttle quadrant is conducive to inadvertent actuation. Problem still exists on A-4.

7 **CLASS DESK ACTION**
– Dispute. Contends spec met, switch is optimally located, that deficiency will be alleviated thru pilot usage, and ECP required to change. NATC disagrees with GAC response.

9 **ACTIONS**
– (A) NAVPRO LTR EN-401: 1 Feb 74. Notification of deficiency to GAC. (B) GAC LTR CTR (222)/474-1721: 11 Apr 74. Contractor's position stated: condition will be alleviated thru continuous pilot exposure to aircraft system operations.

SPEC/STD Violations - - -

MILSD1472 PARA. 5.4.2.1

MILSD203E PARA. 4.7E

KEYWORDS:

Inadvertent Activation
External Lights Master Switch
Vulnerability
Pilot
Hands
Arms
Wrists
Flaps
Throttles
Night Operations
Approach Power Compensator Switch
Air Inlet Control System (AICS)
Switches
Half-Moon Guard
Alternate Action Pushbutton
Friction
Control Panel
Position
Control Equipment

DETAILED DEFICIENCY REPORT (EXAMPLE #3)

APPENDIX F

DEPARTMENT OF THE NAVY
NAVAL AIR SYSTEMS COMMAND
WASHINGTON, D.C. 20361

ACTION

IN REPLY REFER TO
53130:JCH
Ser 314:
AUG 9 1978

From: Commander, Naval Air Systems Command

To: Commander, Naval Air Test Center, Patuxent River, Maryland

Subj: Automated Tracking of F-18 Deficiencies

Ref: (a) COMNAVAIRTESTCEN ltr Ser SA18/544 of 3 Jan 1978
(b) NAVAIRSYSCOM RDT&E FLAG System Volumes I, II and III by John C. Hemingway and CDR Paul R. Chatelier, NAVAIRSYSCOM, Washington, D.C. of Feb 1977

Encl: (1) Sample Detailed Deficiency Report
(2) Sample Deficiency Report Status Summary

1. Reference (a) highlighted the need for an automated system of tracking the status and disposition of F-18 weapon system deficiency reports and recommended that the Naval Air Systems Command (NAVAIRSYSCOM) F-18 Program Manager (PMA-265) employ a derivative of the existing NAVAIRSYSCOM Feedback Loop Action Generation (FLAG) System (described in reference (b)) for this purpose. During the past several months, AIR-531 and the Naval Air Test Center (NAVAIRTESTCEN) F-18 Program Office have reviewed existing FLAG System capabilities in the light of recent F-14 Deficiency Report management experience in order to anticipate NAVAIRSYSCOM and NAVAIRTESTCEN F-18 program Deficiency Report management and processing requirements. Enclosures (1) and (2) contain the revised system output formats which are expected to satisfy F-18 program Deficiency Report management needs.

2. In order to "debug" the revised FLAG system and have it in operation by the start of F-18 testing in January 1979, AIR-5102F, AIR-531 and AIR-503Z will work with the cognizant AIR-05 F-18 Project Support Officers (PSOs) in upcoming months to initialize the system with existing F-18 Design Review Request for Action (RFA), Proposed Specification Change Note (PSCN) transactions and mockup chits. The tracking of deficiencies, starting with the RFA's and continuing throughout the life cycle of the F-18 program, will allow documentation of technical decisions for each deficiency and provide significant improvement in the preparation, review and management of deficiency reports.

3. The degree of correlation between the RFA/PSCN/mockup chit entries and subsequent F-18 FSD deficiency reports is expected to provide COMNAVAIRSYSCOM with a report card on the effectiveness of the F-18 design review process. In a similar manner, correlations and discrepancies between

SAF-019

5313D:JCH
Ser 314

Subj: Automated Tracking of F-18 Deficiencies

F-18 FSD Deficiency Reports, the corresponding NAVAIRSYSCOM decisions, and subsequent fleet Unsatisfactory Report submissions will provide COMNAVAIRSYSCOM with a means to measure the effectiveness of the entire F-18 development program, the impact of FSD program funding constraints, and the decision-making batting average of key participants, including the contractor's engineering and management team. It is anticipated that this comprehensive documentation will have an overall enhancing effect upon the quality of decisions made during F-18 FSD, as well as future NAVAIRSYSCOM programs.

4. Upon completion of FLAG computer program initialization with F-18 RFA/PSCN/mockup chit information, AIR-5102F and AIR-531 will provide all NAVAIRSYSCOM and field activity participants with more definitive information on the use of the FLAG System. The decision to recommend use of the FLAG System on other NAVAIRSYSCOM weapon system development programs will be made by AIR-510 following review of the F-18 initialization effort. In the interim, suggestions and recommendations to further improve and adapt the Flag System and enclosures (1) and (2) to user needs should be forwarded to AIR-531 (J. Hemingway, AIR-5313D, AV-222-7487).

H J Smith

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SAMPLE
DETAILED DEFICIENCY REPORT

DR F18A SA121A 2/79

****

STATUS: 7/79 SERIOUSNESS: II RESPONSIBILITY: K ORIG: SY70

WUC/WBS: 45236/1210.20 BuNo: 160775 EQUIPMENT TYPE :

ECP :

1 TITLE:

- LACK OF MEANS TO INHIBIT INADVERTENT ACTIVATION OF EXTERNAL LIGHT MASTER SWITCH.

2 DISCREPANCY SUMMARY

- LOCATION OF EXTERNAL LIGHTS MASTER SWITCH MAKES IT VULNERABLE TO PILOT HAND, ARM, OR WRIST MOVEMENTS DURING FLAP CONFIGURATION CHANGES, WHEN PILOT MUST REACH AROUND THROTTLE TO GRASP FLAP HANDLE.

3 BACKGROUND INFORMATION

- (2/77) MOCKUP CHIT 4917 RECOMMENDED SWITCH BE GUARDED. MOCKUP BOARD DEFERRED DECISION TO NPE. INADVERTENT ACTUATION OF EXTERNAL LIGHTS MASTER SWITCH IS NO PROBLEM PECULIAR TO F-14A ONLY. A-4M WENT THROUGH THROTTLE HANDLE REDESIGN. S-3A ATTEMPTED TO USE HALF-MOON GUARD, BUT WAS REMOVED.

4 TEST ACTIVITY RECOM: NATC

ACTION/(STATUS)

- OPEN - (2/79) CONTRACTOR INVESTIGATE FEASIBILITY OF ADDITION OF GUARD FOR SWITCH.

9/79 - (7/79) AFTER 23 NIGHT FLIGHTS, NATC SHOWS LACK OF GUARD STILL A PROBLEM. RECOM INCORPORATE PROPOSED FIX.

5 CONTRACTOR RECOM: MAC

ACTION/(STATUS)

OPEN - (4/79) CLAIMS THEIR CONFIGURATION IS WITHIN SPEC (MIL-L-006730B) WF. CLAIMS SWITCH OPTIMALLY LOCATED, DEFICIENCY TO BE CORRECTED THROUGH PILOT USAGE.

6 COGNIZANT ENGINEER RECOM: AIR-533DF1

ACTION/(STATUS)

OPEN - (3/79) STD VIOLATION. MCAIR SHOULD FIX.

OPEN - (4/79) MAC PROPOSAL FORWARDED TO AIR5102F WITH AIR5313 ENDORSEMENT.

OPEN - (5/79) FURTHER NAVY STUDY OF IMPACT DURING NIGHT FLIGHTS.

7 SUPPORT ENGINEER RECOM: AIR-5313A1

ACTION/(STATUS)

7/79 - (3/79) GUARD OR INCREASED FRICTION TOGGLE SHOULD BE CONSIDERED. DO NOT CONCUR WITH MAC CLAIM THAT PILOT USAGE WILL CORRECT DEFICIENCY. CONTROL PANEL AND SPACE TO RIGHT OF THROTTLE QUADRANT IS CONDUCIVE TO INADVERTENT ACTUATION. PROBLEM STILL EXISTS ON A-4 and S-3.

8 CLASS DESK ACTION: AIR-5102F

ACTION/(STATUS)

6/79 - (3/79) DISPUTE. CONTENDS SPEC MET, SWITCH IS OPTIMALLY LOCATED, THAT DEFICIENCY WILL BE ALLEVIATED THROUGH PILOT USAGE.

CLOSED - (7/79) FIX NOT COST EFFECTIVE.

9 SPEC/STD VIOLATIONS ---

MIL-L-006730B, 3.5.9.7

MILSD1472 PARA. 5.4.2.1

MILSD203E PARA. 4.7E

10 MSG/LTD/FONCONS: (A) NAVPRO LTR EN-401: 1 FEB 74. NOTIFICATION OF DEFICIENCY TO MAC. (B) MAC LTR CTR (222)/474-1721: 11 APR 74. CONTRACTOR'S POSITION STATED: CONDITION WILL BE ALLEVIATED THROUGH CONTINUOUS PILOT EXPOSURE TO AIRCRAFT SYSTEM OPERATIONS.

11 UR: COMNAVAIRPAC 261312 7 JUL 76 REPORTED PREMATURE CATAPULT SHOT OF S-3A DUE TO INADVERTENT EXT. LIGHT ACTUATION.

12 KEY WORDS: GUARDS, EXTERNAL LIGHT, CONTROLS, TOGGLE SWITCH, THROTTLE QUADRANT, NIGHT OPERATIONS.

SAMPLE
DEFICIENCY REPORT STATUS SUMMARY

****

A/C	DR NO.	TITLE	SER	RES
		(STATUS/ACTION DATE; ACTIVITY; ENTRY DATE; RECOM/ACTION)		
F-18	SA121A	LACK OF MEANS TO INHIBIT INADVERTENT ACTIVATION OF EXTERNAL LIGHT MASTER SWITCH.	II	K

9/79 - NATC (7/79) AFTER 23 NIGHT FLIGHTS, NATC SHOWS LACK OF GUARD STILL A PROBLEM. RECOM INCORPORATE PROPOSED FIX.

OPEN - MAC (4/79) CLAIMS THEIR CONFIGURATION IS WITHIN SPEC (MIL-L-006730B) WF. CLAIMS SWITCH OPTIMALLY LOCATED, DEFICIENCY TO BE CONNECTED THROUGH PILOT USAGE.

OPEN - AIR-533D4L (5/79) FURTHER NAVY STUDY OF IMPACT DURING NIGHT CARRIER OPS.

7/79 - AIR-5313B (3/79) GUARD OR INCREASED FRICTION TOGGLE SHOULD BE CONSIDERED. DO NOT CONCUR WITH MAC CLAIM THAT PILOT USAGE WILL CORRECT DEFICIENCY. CONTROL PANEL AND SPACE TO RIGHT OF THROTTLE QUADRANT IS CONDUCIVE TO INADVERTENT ACTUATION. PROBLEM STILL EXISTS IN A-4 AND S-3.

CLSD - AIR-5102F (7/79) FIX NOT COST EFFECTIVE.

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